**Women's and Children's Health Policy Center**

**Johns Hopkins University**

# Strengthen the Evidence for Maternal and Child Health Programs

## National Performance Measure 3 Risk-Appropriate Perinatal Care Evidence Review

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## EXECUTIVE SUMMARY

Risk-appropriate perinatal care is one of fifteen Maternal and Child Health National Performance Measures (NPMs) for the State Title V Block Grant Program. The goal of the NPM is to increase the percentage of very low birth weight (VLBW; <1500 gm) infants born in a hospital with a level III or higher neonatal intensive care unit (NICU). The purpose of this evidence review is to identify evidence-informed strategies for State Title V programs to consider for addressing NPM 3 Risk-Appropriate Perinatal Care.

Nineteen peer-reviewed publications met study inclusion criteria and informed the review. These studies described interventions that were focused on hospitals only, population-based systems only, both hospitals and population-based systems, or both hospitals and population-based systems with a patient component. The population-based systems studies included interventions implemented at the inter-hospital (multiple hospitals) system, state, or national levels. Examples of each type of intervention and its evidence rating are shown below:

| Intervention Category | Example | Evidence Rating |
|---|---|---|
| Hospital only | Continuing education of hospital providers | — |
| Population-based systems only | State policy/ guidelines | Emerging Evidence |
| Hospital + Population-based systems | Continuing education of hospital providers + State policy/ guidelines | Moderate Evidence |
| Patient + Hospital + Population-based systems | Access to provider through hotline + Continuing education of hospital providers + State policy/ guidelines | — |

— indicates insufficient number of studies to assign evidence rating

Four key findings emerged from the review:

1. Interventions implemented at both the hospital and population-based systems levels (e.g., Continuing education of hospital providers + State policy/ guidelines) appeared most effective in increasing risk-appropriate perinatal care.

2. Population-based systems interventions alone appeared less effective.

3. Adding a hospital component to population-based systems interventions appears to support the effectiveness of those interventions, as compared to interventions implemented in population-based systems alone.

4. The evidence of effectiveness for interventions with a patient component is less clear.

In this evidence review, risk-appropriate perinatal care interventions were categorized along an evidence continuum from *Evidence Against* (least favorable) to *Scientifically Rigorous* (most favorable). "Hospital + Population-based systems" interventions were classified as having *Moderate Evidence.* "Population-based systems only" interventions had *Emerging Evidence*. Hospital only interventions and interventions with an additional patient component were not categorized due to the limited number of studies.

It appears that interventions that involve both a hospital and population-based systems component are most effective in increasing risk-appropriate perinatal care. Most interventions with a hospital component included continuing education of hospital providers, suggesting that on-going education of hospital staff and providers may promote increases in risk-appropriate perinatal care. Rigorous data collection and more standardized classification systems are needed to better monitor the current status of regionalized systems of risk-appropriate perinatal care and to understand how implementation of specific interventions affects the percentage of VLBW infants born in level III or higher hospitals.

**ACKNOWLEDGMENTS**

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## INTRODUCTION[†]

Strengthen the Evidence Base for Maternal and Child Health (MCH) Programs is a Health Resources and Services Administration (HRSA)-funded initiative that aims to support states in their development of evidence-based or evidence-informed strategies to promote the health and well-being of MCH populations in the United States. This initiative, carried out through a partnership among Johns Hopkins Women's and Children's Health Policy Center, the Association of Maternal and Child Health Programs, and Welch Library at Johns Hopkins, was undertaken to facilitate the transformation of the MCH Title V Block Grant Program.

A goal of the Strengthen the Evidence project is to conduct reviews that provide evidence of the effectiveness of possible strategies to address the National Performance Measures (NPMs) selected for the 5-year cycle of the Title V MCH Services Block Grant, beginning in fiscal year 2016. States are charged to select eight NPMs and incorporate evidence-based or evidence-informed strategies in order to achieve improvement for each NPM selected.

## BACKGROUND

Risk-Appropriate Perinatal Care, NPM 3, is one of the fifteen MCH NPMs. Eighteen states and jurisdictions selected NPM 3, including Alabama, Alaska, American Samoa, Arkansas, California, Connecticut, Georgia, Illinois, Indiana, Michigan, Mississippi, Missouri, New York, North Carolina, Ohio, Puerto Rico, South Carolina, and Utah.[1] Perinatal regionalization, the establishment of regional systems designating risk-appropriate delivery settings for mothers and infants based on the level of care they require, laid the foundation for current efforts to promote risk-appropriate perinatal care.[2] The goal for NPM 3 Risk-Appropriate

[†] The language used in the Introduction section was crafted by the Strengthen the Evidence team and is consistent across all evidence reviews within this project.

Perinatal Care is to increase the percentage of very low birth weight (VLBW; <1500 gm) infants born in a hospital with a level III or higher (level III+) neonatal intensive care unit (NICU).[3]

According to a 2010 review of very low birth weight infants delivered in risk-appropriate settings, the percentage of VLBW infants born in level III or higher hospitals changed only slightly across all states and jurisdictions between 2000 and 2007 from 74.2% to 74.7%.[4] Healthy People 2020 reported this percentage rose to a high of 77.3% in 2009 before decreasing to 74.5% in 2010.[5] At the state/jurisdiction level, 15 states experienced little fluctuation in the rate (≤2% difference), 23 had improved rates, and 14 had decreased rates between 2000 and 2007 or 2008, the most recent year for which data were available.[4] Five states reported greater than 90% of VLBW births were delivered at level III or higher hospitals, a goal that may not be achievable in all states. Hospital level classification systems and definitions of risk-appropriate care for VLBW births vary by state.[6] Differences across states in the percentage of VLBW births in risk-appropriate settings suggest room for improvement.

Regionalized systems of perinatal care and provision of risk-appropriate care to mothers and infants were first discussed in the 1976 landmark report *Toward Improving the Outcome of Pregnancy* (*TIOP I*) by the Committee on Perinatal Health which included, among others, the March of Dimes, the American Academy of Pediatrics (AAP) and the American College of Obstetricians and Gynecologists (ACOG). *TIOP I* described levels of hospitals within a regionalized perinatal care system and discussed the importance of including a variety of stakeholders in planning and evaluating the outcomes of this system.[7] *TIOP II*, a follow-up report released in 1993, also emphasized accountability as a necessary component of strong regionalized perinatal care systems; it promoted the need to include all stakeholders, especially women who are patients in the system, as members of regional and state perinatal boards to help

guide activities.[8] The report also highlighted regional perinatal data collection efforts for evaluating regionalized systems of risk-appropriate perinatal care. A third edition, *TIOP III* (2010) emphasized the importance of efficiency and accountability along with the need for collaboration, integration, and communication leading to overall quality improvement.[9] The need for consistent state measures of risk-appropriate care was identified as an ongoing- challenge to improving regionalized systems of risk-appropriate perinatal care.

Several organizations have established well-defined guidelines for classifying hospital levels based on the types of care provided to pregnant and postpartum women and infants. AAP classified hospitals into four levels based on their capacity to handle high-risk neonates in their 2012 revised policy statement, *Levels of Neonatal Care*.[10] In some regions, level III hospitals represent the highest level of care, but other regions have level IV units that assume additional responsibilities. The AAP designation of level III neonatal care is based on demonstrated experience as measured by large patient volume, availability of more complex care including ventilation and advanced imaging such as CT and MRI, and access to a variety of pediatric medical and surgical subspecialists on-site or through consultation. Data collection and evaluation are also considered responsibilities of level III hospitals. Level IV units, when available, provide the same care as level III hospitals but have higher levels of on-site expertise and continuous availability of pediatric medical and surgical subspecialists. Level III or level IV regional centers may also be responsible for coordinating development of specialized services, facilitating outreach education to lower level units, establishing maternal transport and neonatal back-transport systems, and collecting and assessing outcomes data.

In 2015, ACOG and the Society for Maternal-Fetal Medicine (SMFM) released *Levels of Maternal Care* which focuses on hospital level classification based on ability to provide high-

risk maternal care in addition to neonatal care.[11] Criteria for classification as a level III maternal care facility includes the ability to manage severe maternal complications, availability of adult medical and surgical subspecialties and continuous availability of maternal-fetal medicine and anesthesia services. Level III centers may also provide coordination and leadership of perinatal networks. Level IV classification also includes coordination and leadership responsibilities, but these hospitals must further demonstrate high levels of clinical expertise in managing pregnant and postpartum women in critical condition and provide on-site adult medical and surgical subspecialists. AAP and ACOG discuss the importance of uniform application of classification criteria and establishment of clear definitions and requirements for each level of care.[10,11] Themes of care coordination, data monitoring and evaluation, and on-going collaborative relationships between different hospital levels of neonatal and maternal care are found throughout both documents.

Delivery of VLBW neonates in risk-appropriate settings is an important public health concern as it has implications for maternal and neonatal health outcomes. In a 2010 meta-analysis of 41 studies, hospital level of care at birth was associated with neonatal or in-hospital mortality for VLBW and very preterm infants, those born at or before 32 weeks gestational age (GA).[12] The meta-analysis estimated a 62% increase in the odds of neonatal or in-hospital mortality for VLBW infants born in non-level III hospitals compared to those born in level III hospitals. The increase in the odds of mortality was higher among extremely low birth weight (ELBW) infants, those born weighing 1000 gm or less.

A 2014 systematic review of eight studies by Rashidian et al. focused on the effectiveness of regionalization of perinatal care services in improving neonatal health outcomes including morbidity and mortality.[13] The authors noted some evidence of improvements in health

outcomes after establishment of risk-appropriate systems of regionalized perinatal care, including increases in the proportion of VLBW births at level III centers in five of the studies they reviewed. They cautioned, however, that the quality of the studies must be considered in making any conclusions, and in particular that available evidence does not allow for strong policy change recommendations.

The objectives of the above reviews were not to guide states' Title V MCH Block Grant efforts related to risk-appropriate perinatal care. To support states and jurisdictions in their strategies to promote access to regionalized systems of risk-appropriate perinatal care, the current review focuses on synthesizing the evidence about risk-appropriate perinatal care interventions to increase VLBW births in risk-appropriate birth sites.

**METHODS**

Studies were identified for review by searching the PubMed, CINAHL Plus, and Cochrane Library online databases. Search strategies varied across databases because of differences in controlled vocabulary, indexing, and syntax. Table 1 shows the detailed search strategy used for each database. The three domains of VLBW, NICU/ Level III hospital, and regionalization/ systems of risk-appropriate care were used to build each search strategy. A library specialist (informationist) was consulted to select appropriate databases and to ensure completeness of the search strategies.

The following inclusion criteria were used:

1. The study was empirical and assessed interventions aimed at increasing the percentage of very low birth weight (VLBW; <1500 gm) deliveries in hospitals with a level III or higher (level III+) neonatal intensive care unit (NICU).

2. The study described interventions that fell under the purview of Title V, as determined by the authors and reviewers.
3. Study design was a randomized, quasi-experimental, or time trend analysis design and included an appropriate comparison group.
4. The study was conducted in the United States or in another high-resource country that is a member of the Organization for Economic Cooperation and Development (OECD).
5. The study was published in English.
6. The study was published in a peer-reviewed journal.
7. The study was published between 01/01/1970 and 06/15/2016.

The results of the search of each database were systematically evaluated for relevant studies. One author (DS) contributed 52 articles (14 unique) to the search. Duplicates were removed before beginning title screening. The title of each article was reviewed; if it appeared related to NPM 3, the abstract was then screened. If the abstract did not indicate whether the study met the inclusion criteria or the abstract was not available, full-text of the article was reviewed. All articles remaining after title and abstract screening were retrieved for detailed full-text review to assess their eligibility for inclusion in the current review.

The lead author (EP) extracted relevant data about study characteristics (setting, sample, LBW/ preterm prevalence, and design); intervention (components, implementation date, and study period); data source(s); measures and classifications of low birth weight (LBW)/ preterm infants and hospital levels; and results. Results were extracted separately for outcomes pertaining to place of delivery for VLBW births and maternal transport. Place of delivery focused on increasing VLBW births in risk-appropriate settings; that is, a level III or higher level hospital, rather than decreasing births in settings such as a level I or non-NICU hospitals. Maternal

transport was included because it is related to the likelihood of a VLBW birth in the recipient, level III or higher, hospital. Maternal transport was evaluated based on increasing transfer of high-risk pregnant women to level III or higher hospitals from lower levels of care.

Studies were categorized into groups and results were compared accordingly. This review categorized studies based on the level at which the intervention was implemented and included hospital, population-based systems, and patient levels. The population-based systems studies included interventions implemented at the inter-hospital (multiple hospitals) system, state, or national levels. Four intervention level categories were created: "Hospital only," "Population-based systems only," "Hospital + Population-based systems," and "Patient + Hospital + Population-based systems."

An evidence continuum assessed evidence-informed interventions aligned with criteria for each category of the continuum. The Robert Wood Johnson *What Works for Health* evidence ratings were adapted to create an evidence continuum tailored for the Strengthen the Evidence project.[14] Evidence rating categories included: *Evidence Against*, *Mixed Evidence*, *Emerging Evidence*, *Expert Opinion*, *Moderate Evidence,* and *Scientifically Rigorous*. Strategies that are characterized by *Emerging Evidence* or more favorable ratings are considered evidence-informed. Table 2 shows the detailed evidence rating criteria which include both study type and study results for each rating.

Interventions identified through evaluation of peer-reviewed literature were placed along the evidence continuum. Assignment to the continuum required that a specific intervention category was evaluated in four or more peer-reviewed studies. Two project team members individually assigned ratings to each intervention category; ratings were compared and discrepancies were discussed by the full project team until a consensus was reached.

## RESULTS

### Search Results

Searches in the PubMed, CINAHL Plus, and Cochrane Library databases were performed on June 15, 2016. The systematic review identified 7,414 records. Searches in PubMed, CINAHL Plus, and Cochrane Library yielded 5,312, 1,536, and 566 records, respectively. An additional 52 records (14 unique) were identified through expert consultation (DS).

Title and abstract screening was conducted for 6,044 records after 1,422 duplicates were removed from the 7,466 total records. During title and abstract review, 5,966 records were excluded. Seventy-eight articles were assessed for full-text eligibility and 59 were excluded due to failure to meet all inclusion criteria. Reasons for study exclusion included: full-text article was not in English; the report was not an evaluation of an intervention; the intervention was not adequately described; no adequate comparison group; place of birth of LBW/ preterm infants was not reported as an outcome; and data for population at risk (the denominator) were not included. Nineteen records qualified for the current review. Figure 1 displays the flow chart for the study selection process.

### Characteristics of Studies Reviewed

The 19 articles included in this review varied in study setting, sample, and design, type of intervention, date of intervention, and hospital level classification criteria. Table 3 reports the detailed characteristics of the studies. Of the 19 studies, seven were time trend analysis designs[15-21] and 12 were quasi-experimental studies with two different study designs (pretest-posttest design[22-32] and pretest-posttest non-equivalent control group design[33]). Fourteen studies were conducted in the United States,[15-20,22,26-30,32,33] two in Australia,[25,31] and one each in France,[21] the United Kingdom,[24] and Canada.[23] The study population/ sample also varied across

studies. LBW/ preterm neonates were included in the population/ sample in all studies. Some studies included all births as the denominator while the remainder focused only on LBW/ preterm births, and the change in their distribution across levels of hospitals

Classification of hospital level also varied substantially among studies. Table 4 provides details about hospital level classification. The hospital level criteria in some studies were based on professional guidelines from external sources, whereas others set local guidelines or did not discuss classification criteria beyond referencing hospital levels as a part of their system. Table 4 also highlights the classification of LBW or preterm birth in each study. Some studies focused on all LBW infants while others concentrated on a subset of LBW infants (e.g., VLBW, ELBW) or on infants classified by specific GA at birth.

**Intervention Components**

Table 5 gives a detailed description of the intervention(s) implemented in each study. It also describes the comparison group in each study, which varied across studies. Table 6 specifies the intervention components from each study and is organized by implementation level. Examples of hospital-level interventions include development or improvement of hospital services and continuing education of providers at a specified hospital. Population-based systems level interventions include components such as state or national policy or guidelines, establishment of perinatal committees or councils, and development of systems for maternal/ in-utero transport between hospitals. Examples of patient level interventions include individual assistance with the transition between different care levels and access to providers through a telephone hotline. The categories “Hospital only,” “Population-based systems only,” “Hospital + Population-based systems,” and “Patient + Hospital + Population-based systems” contained two, four, ten, and three studies, respectively.

**Summary of Study Results**

Study results are presented in detail in Table 7. Results for both place of delivery and maternal transport are reported in this review. Some studies also reported changes in neonatal transport rates.[16,20,23,32] Since the focus of NPM 3 is on place of delivery for VLBW infants, outcomes regarding neonatal transports are not reported in this review. It is difficult to quantify the overall range of increases in risk-appropriate perinatal care as outcomes varied across studies. For example, Hein & Burmesiter (1986) report changes in the distribution of VLBW births among hospitals by level, whereas Tomich & Anderson (1990) report VLBW births as a proportion of total births in hospitals by level. Table 8 summarizes the overall study findings along with subgroup analyses, as deemed relevant by the review authors. The studies in Table 8 are organized by the Intervention Components groups described above.

The results presented in Table 8 for place of delivery demonstrate a mix of favorable and non-significant findings, although most results were favorable. The results of the four studies which reported maternal transport as an outcome were favorable, indicating an increase in maternal transfer to risk-appropriate settings. Two studies reporting maternal transport included development or improvement of services as a focus while three addressed continuing education of hospital providers.

Studies of "Hospital + Population-based systems" interventions appeared to be effective in increasing LBW/ preterm births in risk-appropriate locations. The ten interventions in this category focused on a variety of hospital and population-based systems components. The most common hospital level components included continuing education of hospital providers (n=10), development or improvement of services (n=6), and needs assessment (n=3). Continuing education provided to physicians and nurses included topic-based education as well as

development and reinforcement of screening, referral, and transport guidelines for high-risk patients. Development or improvement of services included establishment or upgrading of level III facilities, addition of pediatric and obstetric specialists in level III hospitals, and improvement of existing services in lower level hospitals. The most common population-based systems level components included maternal/ in-utero transport systems (n=6), perinatal committees/ councils (n=5), state policy/ guidelines (n=3), funding support (n=3), and agreement of level III hospital to accept all patients (n=3).

Studies of "Population-based systems only" interventions appeared less effective. Of the four studies in this category, two showed no significant changes in place of delivery for VLBW births.[21,30,33] One study[24] involving national reorganization of neonatal services indicated favorable findings and a second[31] noted favorable findings associated with changes in place of delivery for infants born at 23 to 24 weeks GA.

There was less clear evidence of effectiveness for studies in which a patient component was added to "Hospital + Population-based systems" components. All three studies in this category were conducted among hospitals in Arkansas. Although two of the three reported favorable findings, they were limited to small shifts in place of delivery and were typically not sustained long-term.[15,17] Kim et al. (2013) reported a decrease in VLBW births in non-NICU hospitals receiving telemedicine intervention, but the intervention was not associated with a significant increase in VLBW births in risk-appropriate settings. No conclusions can be made about these select studies in one state.

**Evidence Rating & Evidence Continuum**

Assignments of evidence ratings were based on VLBW place of delivery results for the 19 studies (Table 8). The intervention categories of "Hospital only" and "Patient + Hospital + Population-based systems" included only two and three studies, respectively, and therefore were not assigned evidence ratings or placed on the evidence continuum.

Based on the evidence rating criteria, shown in Table 2, "Hospital + Population-based systems" interventions were classified as having *Moderate Evidence.* "Population-based systems only" interventions had *Emerging Evidence*. Figure 2 displays the evidence continuum with evidence-informed intervention categories plotted along the continuum.

**IMPLICATIONS**

About one-third of states and jurisdictions selected the Risk-Appropriate Perinatal Care NPM as a programmatic focus for the current 5-year cycle of the Title V MCH Services Block Grant. The purpose of this review was to provide information about evidence-based and evidence-informed interventions to increase the percentage of VLBW infants born in hospitals with a level III or higher NICU.

It appears that interventions that involve both a hospital and population-based systems component are most effective in increasing risk-appropriate perinatal care. Inclusion of a hospital component appears critical. The results across nine of the ten studies which implemented both hospital and population-based systems components were consistently favorable. All of these interventions involved continuing education of hospital providers. This finding suggests that on-going education of hospital staff and providers may be important to increase the percentage of VLBW infants born in risk-appropriate settings. The findings for population-based systems interventions alone showed little evidence of effectiveness. The impact of the addition of a

patient component was unclear, although the number of studies including a patient component was limited to one state.

A major strength of this evidence review is that it focused on interventions with potential impact on increasing the percentage of VLBW births in risk-appropriate settings. There are, however, several limitations. First, only 19 studies met the inclusion criteria. The relatively small number of studies limits the conclusions that may be drawn regarding effective interventions. Second, 11 of the 19 studies were conducted between 1980 and 1991, a period when many regionalized systems of care were evolving. Changes in care systems over time and in recent years may limit the relevance of the findings from these studies. Third, the studies did not address interventions focused on relationships among states, a component of regionalized systems in some more rural areas of the country and in areas which are more proximate to facilities in adjacent states. Fourth, search results were screened and interpreted by one reviewer; nevertheless, a uniform protocol was followed and concerns which arose during this process were addressed by a team of experts.

Fifth, due to differences in classification of hospital levels across states and countries, there may be variation in the care provided at hospitals defined as level III or higher. To address this concern, hospital level criteria were outlined for each study to allow consideration of these differences. Finally, comparing and synthesizing studies was limited due to variations in study setting, sample, and design. Intervention components used in each study varied; while components could be articulated for each study, conclusions were made only for the broad level of interventions rather than individual intervention components. This limited our ability to draw conclusions about specific strategies.

Other factors related to delivery of VLBW births outside of level III or higher hospitals may also be considered when developing or implementing interventions to increase the percentage of VLBW births in risk-appropriate settings. Late prenatal care recipients had lower odds of delivering VLBW babies in a hospital with a NICU (with or without maternal transfer) when compared to women who started prenatal care in the first trimester.[34] It may be necessary for women to enter a system of care with sufficient time for assessment of risk and referral for consultation, given that VLBW births or maternal transports often occur early in the third trimester of pregnancy. Increased distance to the nearest level III hospital may also decrease the percentage of VLBW delivery in these facilities, as reported in studies in Belgium, Denmark, France, Germany, Italy, Poland, Portugal, and the UK[35] as well as in the United States.[36] Although travel time to a level III or higher hospital may be an immediate factor impeding risk-appropriate delivery setting, healthcare facilities and providers in outlying areas in particular may benefit from targeted outreach and education focused on risk-assessment, referral, and transport of women with impending high-risk deliveries.

In addition, concerns have been raised about a decrease in regionalized systems of risk-appropriate perinatal care due to proliferation of level II hospitals with NICUs and increased competition among hospitals for patients. Increase in nearby level II centers has been associated with increased VLBW births in these hospitals and decreased VLBW births in level III hospitals.[37,38] Hospital competition has been cited as one reason for proliferation of level II hospitals.[39]

As discussed by the *TIOP* reports[7-9] and by AAP and ACOG's policy statements on levels of care,[10,11] establishment of comprehensive hospital level classification systems with clear criteria for each level is necessary to understand the extent of regionalized systems of risk-

appropriate perinatal care and to evaluate the impact of state interventions. This concern was highlighted in a 2010 report which showed differences in classification of risk-appropriate care across states.[4] Peer-reviewed literature evaluated in the current review further emphasized significant variation in how hospital levels are described. Tools such as the CDC's Levels of Care Assessment Tool (LOCATe) may help guide states in their efforts to classify hospitals into neonatal and maternal care levels.[40] Rigorous data collection and more standardized classification systems are needed to better monitor the current status of risk-appropriate perinatal care systems and to understand how implementation of specific interventions affects the percentage of VLBW infants born in level III or higher hospitals.

**FIGURES & TABLES**

**Figure 1. Flow Chart of the Review Process and Results.**

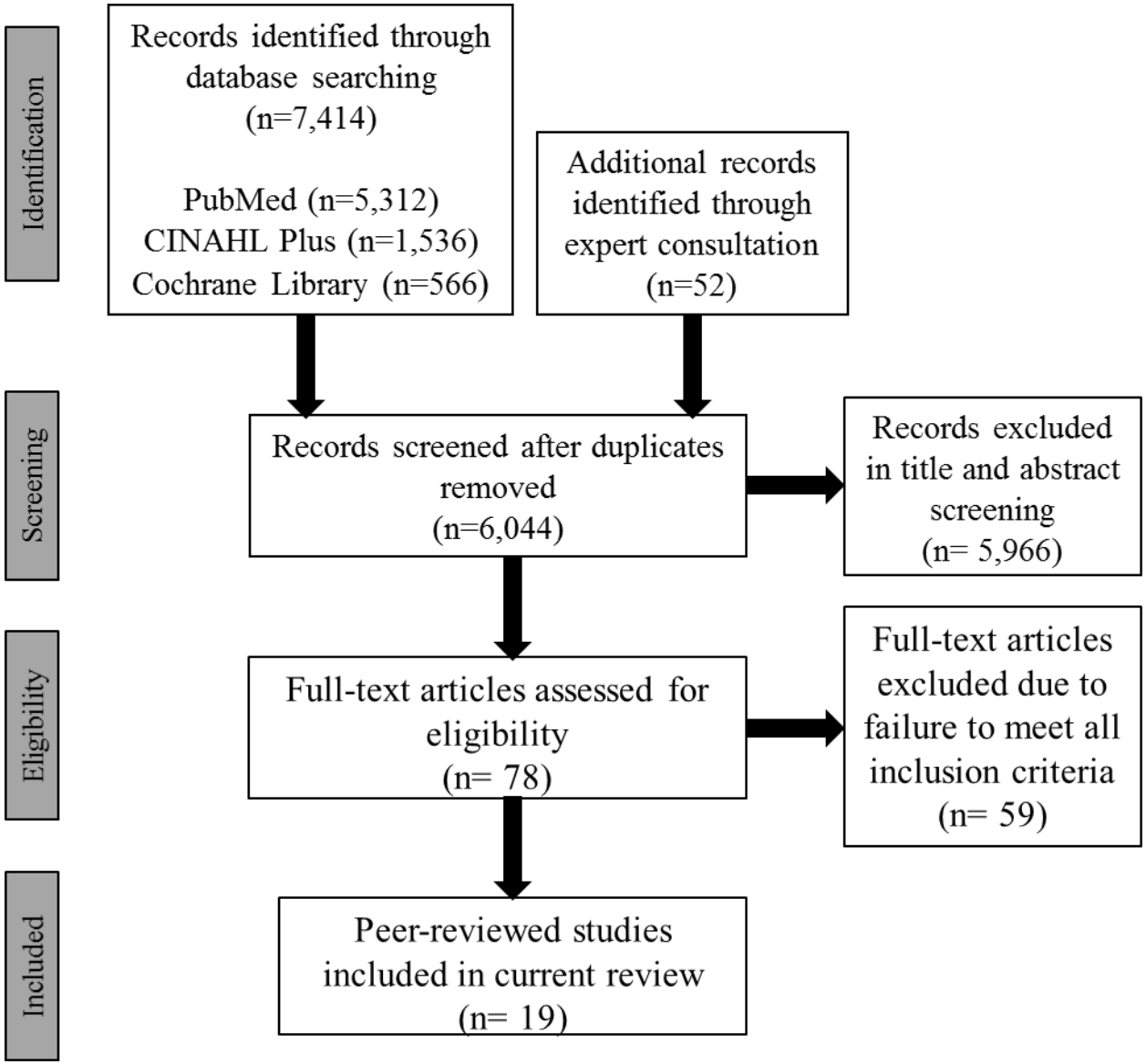

**Figure 2. Evidence Continuum.**

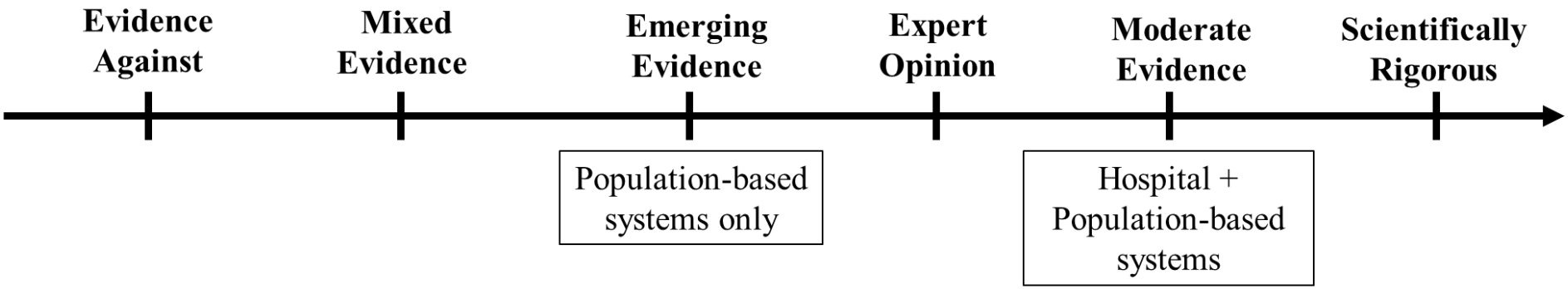

**Table 1. Detailed Search Strategies.**

| Database | Search Strategies |
|---|---|
| **PubMed** | "Infant, Low Birth Weight"[Mesh] OR "Infant, Very Low Birth Weight"[Mesh] OR "Infant, Extremely Low Birth Weight"[Mesh] OR "Infant, Premature"[Mesh] OR "Premature Birth"[Mesh] OR "Pregnancy, High-Risk"[Mesh] OR "Obstetric Labor, Premature"[Mesh] OR LBW[tw] OR VLBW[tw] OR ELBW[tw] OR 500 gram*[tw] OR 750 gram*[tw] OR 1000 gram*[tw] OR 1500 gram* [tw] OR birth weight*[tw] OR birthweight*[tw] OR ((preterm[tw] OR "pre term"[tw] OR premature[tw] OR "pre mature"[tw]) AND (infant*[tw] OR neonat*[tw] OR birth*[tw] OR newborn*[tw])) OR (("high risk"[tw]) AND (pregnant*[tw] OR pregnanc*[tw] OR mother*[tw] OR maternal*[tw] OR birth*[tw] OR infant*[tw] OR newborn*[tw] OR neonat*[tw])) |
| | "Intensive Care Units, Neonatal"[Mesh] OR "Neonatal Intensive Care"[tw] OR "Newborn Intensive Care"[tw] OR Neonatal ICU*[tw] OR Newborn ICU*[tw] OR NICU*[tw] OR "level III"[tw] OR "level 3"[tw] OR tertiary[tw] OR perinatal center*[tw] OR regional center*[tw] OR subspecialty[tw] OR hospital level*[tw] |
| | "Regional Health Planning"[Mesh] OR "Delivery of Health Care, Integrated"[Mesh] OR "Health Services Accessibility"[Mesh] OR "Telemedicine"[Mesh] OR "Referral and Consultation"[Mesh] OR "Patient Transfer"[Mesh] OR regional*[tw] OR deregional*[tw] OR referral*[tw] OR transfer*[tw] OR transport* [tw] OR "risk appropriate"[tw] OR telemedicine[tw] OR "tele medicine"[tw] OR telehealth[tw] OR "tele health"[tw] OR mhealth[tw] OR "mobile health"[tw] OR collaborat*[tw] OR system*[tw] OR outreach[tw] OR interagency agreement*[tw] OR guideline*[tw] OR interfacilit*[tw] OR integrated[tw] |
| | #1 AND #2 AND #3 |
| **CINAHL Plus** | (MH "Infant, Low Birth Weight+") OR (MH "Infant, Very Low Birth Weight") OR (MH "Infant, Premature") OR (MH "Childbirth, Premature") OR (MH "Pregnancy, High Risk") OR (MH "Labor, Premature") OR TI(LBW OR VLBW OR ELBW OR 1500 gram* OR 1000 gram* OR 500 gram* OR 750 gram* OR birth weight* OR birthweight*) OR AB (LBW OR VLBW OR ELBW OR 1500 gram* OR 1000 gram* OR 500 gram* OR 750 gram* OR birth weight* OR birthweight*) OR ((TI (preterm OR "pre term" OR premature OR "pre mature") OR AB(preterm OR "pre term" OR premature OR "pre mature")) AND (TI ( infant* OR neonat* OR birth* OR newborn*) OR AB(infant* OR neonat* OR birth* OR newborn* ))) OR ((TI("high risk") OR AB("high risk")) AND (TI(pregnant* OR pregnanc* OR mother* OR maternal* OR birth* OR infant* OR newborn* OR neonat*) OR AB(pregnant* OR pregnanc* OR mother* OR maternal* OR birth* OR infant* OR newborn* OR neonat*))) |
| | (MH "Intensive Care Units, Neonatal") OR TI(("Neonatal intensive care" OR "newborn intensive care" OR neonatal ICU* OR newborn ICU* OR NICU* OR "level III" OR "level 3" OR tertiary OR perinatal center* OR regional center* OR subspecialty OR hospital level*) OR AB("Neonatal intensive care" OR "newborn intensive care" OR neonatal ICU* OR newborn ICU* OR NICU* OR "level III" OR "level 3" OR tertiary OR perinatal center* OR regional center* OR subspecialty OR hospital level*) |
| | (MH "Referral and Consultation+") OR (MH "Transfer, Discharge") OR (MH "Telemedicine+") OR (MH "Telehealth+") OR (MH "Health Care Delivery, Integrated") OR TI(regional* or deregional* or referral* or transfer* or transport* or "risk appropriate" or telemedicine or "tele medicine" or telehealth or "tele health" or mhealth or "mobile health" or collaborat* or system* or outreach or interagency agreement* or guideline* or interfacilit* OR integrated) OR AB(regional* or deregional* or referral* or transfer* or transport* or "risk appropriate" or telemedicine or "tele medicine" or telehealth or "tele health" or mhealth or "mobile health" or collaborat* or system* or outreach or interagency agreement* or guideline* or interfacilit* OR integrated) |
| | S1 AND S2 AND S3 |
| **Cochrane Library** | #1 MeSH descriptor: [Infant, Low Birth Weight] explode all trees |
| | #2 MeSH descriptor: [Infant, Very Low Birth Weight] explode all trees |
| | #3 MeSH descriptor: [Infant, Extremely Low Birth Weight] explode all trees |
| | #4 MeSH descriptor: [Infant, Premature] explode all trees |
| | #5 MeSH descriptor: [Premature Birth] explode all trees |
| | #6 MeSH descriptor: [Pregnancy, High-Risk] explode all trees<br>#7 MeSH descriptor: [Obstetric Labor, Premature] explode all trees |
| | #8 (LBW or VLBW or ELBW or 1500 gram* or 1000 gram* or 500 gram* or 750 gram* or birth weight* or birthweight*):ti,ab,kw |
| | #9 (preterm or "pre term" or premature or "pre mature"):ti,ab,kw |

| | |
|---|---|
| | #10 (infant* or neonat* or birth* or newborn*):ti,ab,kw |
| | #11 #9 and #10 |
| | #12 "high risk":ti,ab,kw |
| | #13 (pregnant* or pregnanc* or mother* or maternal* or birth* or infant* or newborn* or neonat*):ti,ab,kw |
| | #14 #12 and #13 |
| | #15 #1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #11 or #14 |
| | #16 MeSH descriptor: [Intensive Care Units, Neonatal] explode all trees |
| | #17 ("Neonatal intensive care" or "newborn intensive care" or neonatal ICU* or newborn ICU* or NICU* or "level III" or "level 3" or tertiary or perinatal center* or regional center* or subspecialty or hospital level*):ti,ab,kw |
| | #18 #16 or #17 |
| | #19 MeSH descriptor: [Regional Health Planning] explode all trees |
| | #20 MeSH descriptor: [Referral and Consultation] explode all trees |
| | #21 MeSH descriptor: [Patient Transfer] explode all trees |
| | #22 MeSH descriptor: [Telemedicine] explode all trees |
| | #23 MeSH descriptor: [Delivery of Health Care, Integrated] explode all trees |
| | #24 MeSH descriptor: [Health Services Accessibility] explode all trees |
| | #25 (regional* or deregional* or referral* or transfer* or transport* or "risk appropriate" or telemedicine or "tele medicine" or telehealth or "tele health" or mhealth or "mobile health" or collaborat* or system* or outreach or interagency agreement* or guideline* or interfacilit* or integrated):ti,ab,kw |
| | #26 #19 or #20 or #21 or #22 or #23 or #24 or #25 |
| | #27 #15 and #18 and #26 |

**Table 2. Evidence Rating Criteria.**

| Evidence Rating | Evidence Criteria: Type | Evidence Criteria: Study Results |
|---|---|---|
| Scientifically Rigorous | • Peer-reviewed study results are drawn only from:<br>o Randomized controlled trials, and/ or<br>o Quasi-experimental studies with pre-post measures and control groups | • Preponderance of studies have statistically significant favorable findings |
| Moderate Evidence | • Peer-reviewed study results are drawn from a mix of:<br>o Randomized controlled trials<br>o Quasi-experimental studies with pre-post measures and control groups<br>o Quasi-experimental studies with pre-post measures without control groups<br>o Time trend analyses | • Preponderance of studies have statistically significant favorable findings |
| Expert Opinion | • Gray literature | • Experts deem the intervention as favorable based on scientific review |
| Emerging Evidence | • Peer-reviewed study results are drawn from a mix of:<br>o Randomized controlled trials<br>o Quasi-experimental studies with pre-post measures and control groups<br>o Quasi-experimental studies with pre-post measures without control groups<br>o Time trend analyses<br>o Cohort studies | • Studies with a close-to-evenly distributed mix of statistically significant favorable and non-significant findings<br>• Only cohort studies with preponderance of statistically significant favorable findings |
| | • Gray literature | • Experts deem the intervention as favorable |
| Mixed Evidence | • Peer-reviewed study results are drawn from a mix of:<br>o Randomized controlled trials<br>o Quasi-experimental studies with pre-post measures and control groups<br>o Quasi-experimental studies with pre-post measures without control groups<br>o Time trend analyses<br>o Cohort studies | • Studies with a close-to-evenly distributed mix of statistically significant favorable, unfavorable, and non-significant findings |
| | • Gray literature | • Experts deem the intervention as having mixed evidence |
| Evidence Against | • Peer-reviewed study results are drawn from a mix of:<br>o Randomized controlled trials<br>o Quasi-experimental studies with pre-post measures and control groups<br>o Quasi-experimental studies with pre-post measures without control groups<br>o Time trend analyses<br>o Cohort studies | • Preponderance of studies have statistically significant unfavorable or non-significant findings |
| | • Gray literature | • Experts deem the intervention as being ineffective or unfavorable |

**Table 3. Study Characteristics**

| Study | Country | Setting | Study sample | Prevalence of LBW/ Preterm[2] | Study design |
|---|---|---|---|---|---|
| Bowes (1981) | US | All Colorado hospitals<br><br>Three level III, seven level II, remaining level I | Pretest (n= 154,208)<br>Posttest (n= 164,832)<br><br>Infants born weighing greater than one lb. | Pretest: 1.8% (n=2,818)<br><br>Posttest: 1.8% (n=2,967)<br><br>Infants born weighing one to four lbs. | QE: pretest-posttest |
| Bronstein et al. (2011) | US | All Arkansas hospitals<br><br>Five level III hospitals from 2001-2005, six in 2006 | Total (n= 5,150)<br>2001 (n= 812)<br>2002 (n= 1,105)<br>2003 (n= 824)<br>2004 (n= 824)<br>2005 (n= 887)<br>2006 (n= 698)<br><br>Infants born at <35 weeks GA | NR | Time trend analysis |
| Campbell et al. (1991) | Canada | Southwestern Ontario<br><br>One level III, one modified level III and 30 level II or I | Pretest (n= 16,579)<br>Posttest (n= 16,082)<br><br>Births greater than 500 gm | Pretest: 1.17% (n= 194)<br>Posttest: 1.31% (n= 211)<br><br>Infants born weighing 500-1499 gm | QE: pretest-posttest |
| Cowett et al. (1986) | US | Rhode Island and southeastern Massachusetts<br><br>One tertiary center and 13 other obstetric facilities | 1973 (n=5,300)<br>1984 (n=7,317)<br><br>Total live births >500 gm in tertiary center | Pretest: 6.7% (n≈ 355)<br>Posttest: 8.7% (n≈ 636)<br><br>Infants born weighing 500-2499 gm at tertiary center | Time trend analysis |
| Gale et al. (2012) | United Kingdom | Pretest: 294 maternity centers and neonatal units in England, Wales and Northern Ireland<br><br>Posttest: 146 neonatal units (23 managed clinical networks) in England | Pretest (n=3,522)<br>Posttest (n=2,919)<br><br>Infants born at $27^{+0}$ to $28^{+6}$ (weeks+ days) GA<br><br>In pretest, live births<br><br>In posttest, admitted to a neonatal unit (no details on babies who died in labor ward) | NR | QE: pretest-posttest |

| Study | Country | Setting | Study sample | Prevalence of LBW/ Preterm[2] | Study design |
|---|---|---|---|---|---|
| Hall et al. (2010) | US | All Arkansas hospitals | Total (n= 12,258)<br>2001 (n= 2,965)<br>2004 (n= 3,154)<br><br>Infants born weighing 500-2499 gm. Data not given for other study years. | NR | Time trend analysis |
| Hein (1980) | US | All Iowa hospitals<br><br>Pretest: 130 level I, 10 level II, and one level III hospital<br><br>Posttest: 122 level I, 10 level II, and one level III hospital | Pretest (n= 440)<br>Posttest (n= 402)<br><br>All live births <1500 gm | NR | QE: pretest-posttest |
| Hein & Burmeister (1986) | US | All Iowa hospitals<br><br>Pretest: 129 level I, 11 level II, and one level III hospital<br><br>Posttest: 118 level I, 11 level II, and one level III hospital | Pretest (n= 432)<br>Posttest (n= 343)<br><br>All infants born at ≥20 weeks GA and ≤1500 gm | NR | QE: pretest-posttest |
| Hoekstra et al. (1981) | US | Minnesota: Abbott-Northwestern/ Minneapolis Children's Perinatal Center and Fairview-Southdale Hospital (Level II) | Pretest (n= 2,573)<br>Posttest (n= 2,722)<br><br>All births at level II hospital | 1978: 0.31% (8)<br>1980: 0% (0)<br><br>Infants born weighing ≤1500 gm at level II hospital | QE: pretest-posttest |
| Kim et al. (2013) | US | All Arkansas hospitals (Nine selected as telemedicine hospitals due to high patient volume) | Pretest (n= 383)<br>Posttest (n= 384)<br><br>Infants born weighing <1500 gm | NR | QE: pretest-posttest |
| Lessaris et al. (2002) | US | All coastal South Carolina hospitals: Includes one level III hospital | Pretest (n= 255)<br>Posttest (n= 265)<br><br>Infants born weighing <1500 gm | NR | QE: pretest-posttest |
| Lui et al. (2006) | Australia | New South Wales, Australia hospitals<br><br>Seven perinatal centers | Pretest (n= 1,778)<br>Posttest (n= 3,099) | NR | QE: pretest-posttest |

| Study | Country | Setting | Study sample | Prevalence of LBW/ Preterm[2] | Study design |
|---|---|---|---|---|---|
| | | | Infants born between $23^{+0}$ and $28^{+6}$ weeks GA who did not die before or during retrieval. | | |
| McCormick et al. (1985) | US | Eight regions and eight comparison regions | Intervention group:<br>Pretest (n≈ 4080)<br>Intervention (n≈ 3416)<br>Posttest: (n≈ 4033)<br><br>Comparison:<br>Pretest: (n≈ 5221)<br>Intervention: (n≈ 4297)<br>Posttest: (n≈ 4596)<br><br>Infants born weighing ≤1500 | NR | QE: pretest-posttest non-equivalent control group |
| Nugent (1982) | US | Non-federal North Carolina hospitals | Percentages given without numerator or denominator.<br><br>Infants born weighing ≤1500 gm | NR | Time trend analysis |
| Powers & McGill (1987) | US | Illinois North Central Perinatal Region: 31 hospitals including one tertiary center | 1973 (n= 100) 1974 (n= 104)<br>1975 (n= 102) 1976 (n= 88)<br>1977 (n= 102) 1978 (n= 97)<br>1979 (n= 101) 1980 (n= 85)<br>1981 (n= 100) 1982 (n= 83)<br>1983 (n= 81)<br><br>Infants born weighing 1001 to 1500 gm | NR | Time trend analysis |
| The VICSG (1991) | Australia | All hospitals in Victoria, Australia | Pretest (n= 351)<br>Posttest (n= 560)<br><br>Infants born weighing 500-999 gm | NR | QE: pretest-posttest |
| Tomich & Anderson (1990) | US | Metropolitan Chicago: Cook County and Suburban Dupage County<br><br>Two level I, 11 level II, and one level III hospitals | 1981 (n= 18,365)<br>1982 (n= 19,460)<br>1983 (n= 19,162)<br>1984 (n= 19,379)<br>1985 (n= 20,132)<br>1986 (n= 19,751) | 1981 (n= 322)<br>1982 (n= 289)<br>1983 (n= 304)<br>1984 (n= 324)<br>1985 (n= 270)<br>1986 (n= 240) | Time trend analysis |

| Study | Country | Setting | Study sample | Prevalence of LBW/ Preterm[2] | Study design |
|---|---|---|---|---|---|
| | | | Infants born weighing >500 gm. Data for entire region only given from 1981-1986. | Infants born weighing 500-1500 gm | |
| Vendittelli et al. (2012) | France | French hospitals | Percentages given without numerator or denominator.<br><br>Subsample of all infants born weighing <1500 gm<br><br>Data from 1994 to 1998 only included singleton pregnancies. | NR | Time trend analysis |
| Warner et al. (2002) | US | Ohio, TriHealth Hospital System<br><br>Two level II and one level III hospital | Total sample size not given for pretest and posttest periods. | NR | QE: pretest-posttest |

[1] Abbreviations used in this table: QE (quasi-experimental study), NR (not reported)
[2] Prevalence of LBW/ Preterm was only calculated for studies in which the study population/ sample was total births.

**Table 4. Classifications & Measures.**

| Study | Source of Data | Measures of LBW/ Preterm | Hospital Level Classification |
|---|---|---|---|
| Bowes (1981) | Data from the Bureau of Vital Records, Colorado State Health Department. | Infants weighing one to four lbs. | • Level I, II, and III hospitals<br>• Levels of perinatal services provided by each hospital corresponded to the description in *Toward Improving the Outcome of Pregnancy* (1976)<br>• Colorado Perinatal Care Council made unofficial designations of level II and level III hospitals |
| Bronstein et al. (2011) | Data from Medicaid claims for pregnancy linked to birth certificates for women covered by Medicaid in Arkansas. | Births to Medicaid-covered women in Arkansas before 35 weeks gestational age (GA; as recorded on birth certificate based on reported last menstrual period, adjusted for compatibility with recorded birth weight) | • No state-based categorization of care<br>• Hospital considered level III if they had a neonatologist on staff and maintained long-term ventilation support for newborns<br>• Neonatology-staffed hospitals in surrounding states counted as appropriate care sites when preterm infants delivered there |
| Campbell et al. (1991) | Data obtained from hospital delivery room books and for 31 of the 32 hospitals, from hospital charts of women and neonates. | Infants weighing 500-1499 gm | • The article cites *Family-Centred Maternity and Newborn Care: National Guidelines* when describing hospital levels<br>• Level I facilities manage births without significant identifiable risks<br>• Level II facilities: Provide level I care and can handle select high-risk situations such as preterm birth at >32 weeks GA<br>• Modified level III centers: Not university-based and can handle most high-risk situations with the exception of infants born weighing <1000 gm or at <28 weeks GA<br>• Level III regional perinatal centers: Provide level I and II care and care for pregnant women and infants at high risk |
| Cowett et al. (1986) | Data from annual hospital statistics. Maternal transport data only available for 1978 and later. | Infants weighing <2500 gm | • Tertiary center and other obstetric facilities<br>• Did not indicate further criteria for classification |
| Gale et al. (2012) | Pretest: Data from a published report of the Confidential Enquiry into Stillbirths and Deaths in Infancy Project 27/28 which identified 28 day outcomes of all live births at 27-28 weeks GA in England, Wales, and Northern Ireland.<br><br>Posttest: Data from National Neonatal Research Database held by the Neonatal Data Analysis Unit. | Infants between $27^{+0}$ to $28^{+6}$ (weeks+ days) GA (do not describe GA acquisition method) | • Hospitals classified by volume of neonatal specialist care as defined by number of intensive care days<br>• Categories included 1-499, 500-999, 1000-1499, 1500-1999, and ≥2000 annual intensive care days with ≥2000 representing the highest level of care<br>o Three hospitals with ≥2000 intensive care days were considered level II (provided high dependency care and some short term intensive care) hospitals according to the British Association of Perinatal Medicine guidelines |

| Study | Source of Data | Measures of LBW/ Preterm | Hospital Level Classification |
|---|---|---|---|
| Hall et al. (2010) | Data from Arkansas Vital Statistics Data System linked with corresponding hospitalization records from Arkansas Hospital Discharge Data System. | Infants weighing 500-1499 gm subdivided into 500-999 gm and 1000-1499 gm groups. | • Three categories of hospitals:<br>o State's academic medical center (University of Arkansas for Medical Science; UAMS) which had 24-hr. coverage by maternal-fetal medicine subspecialists and in-house faculty neonatologists<br>o Community hospitals with NICUs with neonatology coverage<br>o Community hospitals without neonatology coverage |
| Hein (1980) | Data from Iowa State Health Department matched birth and infant death certificates. | Infants weighing <1500 gm | • Level I facilities: Small community hospitals with < 500 deliveries per year and larger community hospitals with > 500 deliveries not designated level II perinatal centers<br>• "Regional Level II facilities": Designated because of low population density in Iowa. Centers were staffed by pediatricians and obstetricians with special interest in providing high-risk care; most were not Board-eligible or -certified in maternal/fetal medicine or neonatal/perinatal medicine, but all received ongoing postgraduate education in perinatal care. Level II centers had the capability of rapidly transporting high risk women to the tertiary center.<br>• University of Iowa Hospital: Only level III hospital in the state; the criteria for a level III center were not outlined |
| Hein & Burmeister (1986) | Data from Iowa State Health Department matched birth and infant death certificates. | Infants weighing ≤1500 gm | • See Hein (1980). |
| Hoekstra et al. (1981) | Data source not provided. | Infants weighing ≤1500 gm born at level II hospital | • Level II and III hospitals<br>• Did not indicate further criteria for classification |
| Kim et al. (2013) | Medicaid data for VLBW infants as indicated by ICD-9 diagnosis codes from hospital and physician claims for pregnancy. Data infant with birth and infant death certificates. | Infants born weighing <1500 gm | • Hospital levels broken down into categories:<br>o Telemedicine (TM) with NICU, TM without NICU, non-TM with NICU, non-TM without NICU, and UAMS<br>• UAMS considered the tertiary center |
| Lessaris et al. (2002) | Data source not provided. | Infants weighing <1500 gm | • Level I hospitals: Provide basic care<br>• Level II hospitals: Specialty perinatal centers which provide management for certain high-risk pregnancies and newborns with certain complications as well as receive referrals from level I hospitals<br>• Level III centers: Subspecialty perinatal centers providing inpatient care for maternal and fetal complications |

| Study | Source of Data | Measures of LBW/ Preterm | Hospital Level Classification |
|---|---|---|---|
| Lui et al. (2006) | Baseline population data for all births between 23 and 28 weeks GA obtained from the New South Wales Midwives Data Collection. | Infants between $23^{+0}$ and $28^{+6}$ weeks GA (do not describe GA acquisition method) who did not die before or during retrieval. | • Two of seven perinatal centers offered pediatric surgery<br>• Did not indicate further criteria for classification |
| McCormick et al. (1985) | Data from reproduced computer tapes of births and matched infant death and birth certificates obtained from state and local health offices in several states. | Infants born weighing ≤1500 gm | • Tertiary center: Averaged >1,000 deliveries per year over the decade as indicated in the American Hospital Association (AHA) guide and had a NICU in the AHA Guide of 1980 and/or in the list of such units compiled by Ross Laboratories |
| Nugent (1982) | Data source not provided. | Infants weighing ≤1500 gm | • Based on guidelines from *Towards Improving the Outcome of Pregnancy* and state Task Force on Maternal and Infant Health<br>• Level I hospitals: Provide care for normal patients and those with a few immediate complications<br>• Level II hospitals: Provide care for the majority of patients with complications<br>• Level III hospitals: Provide intensive care of those with serious illnesses or extreme prematurity |
| Powers & McGill (1987) | Data from 1973-1982 obtained from the Illinois Department of Public Health live birth files. Data from 1983 from an Illinois Department of Public Health administered monthly hospital reporting system. | Infants weighing 1001- 1500 gm | • Tertiary care center<br>• Did not indicate further criteria for classification |
| The VICSG (1991) | Data from the Victorian Perinatal Data Collection Unit (with linkages to death certificates) and cross-checked with data from each level III hospital in the state and the Newborn Emergency Transport Service. | Infants weighing 500-999 gm | • Level I, II, and III hospitals<br>• Did not indicate further criteria for classification |
| Tomich & Anderson (1990) | Data obtained from the Illinois Department of Public Health and Loyola University annual statistics reports. | Infants weighing 500-1500 gm | • Level I, II, and III centers<br>• Did not indicate further criteria for classification |
| Vendittelli et al. (2012) | Data from the voluntary Audipog database in which participating hospitals send data on all deliveries covering a given period of at least a full month (chosen by hospital) each | Infants weighing <1500 gm | • Level III unit was a maternity ward equipped with a NICU |

| Study | Source of Data | Measures of LBW/ Preterm | Hospital Level Classification |
|---|---|---|---|
| | year. Authors extracted a subsample from the data. | | |
| Warner et al. (2002) | Data from the National Institute of Child Health and Human Development Neonatal Research Network registry, the Regional Perinatal Database, and hospital records. | Infants weighing 500-1499 gm | • Level II and III hospitals<br>• Did not indicate further criteria for classification |

**Table 5. Intervention Description.**

| Study | Comparison Group | Intervention | Intervention Implementation | Study Period |
|---|---|---|---|---|
| Bowes (1981) | N/A | • Voluntary and non-directive regionalization of neonatal and obstetric intensive care without external funding<br>• Establishment of Colorado Perinatal Care Council, a voluntary council, meeting on a regular basis and representing a wide range of individuals interested in perinatal health<br>• 1974: Funding given to Denver Children's Hospital and University of Colorado Medical Center- conducted an outreach continuing education program throughout the state for several hospitals providing obstetric and newborn care | 1975 | Pretest: 1971-74<br>Posttest: 1975-78 |
| Bronstein et al. (2011) | N/A | • Arkansas Antenatal and Neonatal Guidelines, Education and Learning System (ANGELS)<br>o Development of consensus practice guidelines<br>o Weekly telemedicine conferences on obstetric topics<br>o 24/7 call center at University of Arkansas for Medical Sciences (UAMS)<br>▪ Provided provider consultations and arranged maternal transport to UAMS<br>▪ Allowed calls from women concerned with pregnancy complications<br>o Enhanced telemedicine system supports remote consults | 2003 | Time trends between April 2001 and December 2006 |
| Campbell et al. (1991) | N/A | • 1972: Ontario Ministry of Health began encouraging regionalization of perinatal care<br>• Establishment of regional perinatal advisory committees and efficient maternal transport system; transfer out of province if needed<br>• Provincial perinatal bed registry providing information on availability of space in level III centers<br>• Since 1980: Voluntary participation in perinatal outreach educational program<br>o Hospital visit at least once per year to present on perinatal care topics and follow-up on referred patients<br>o Program of nursing education<br>o Transfer encouraged for women in need of a higher level of care than available locally | Component one: 1972<br>Component two: 1980 | Pretest: 1982<br>Posttest: 1985 |
| Cowett et al. (1986) | N/A | • 1974: Began level III operation with establishment of special care nursery at hospital<br>• 1978: Addition of maternal-fetal medicine program at level III hospital with a strong emphasis on maternal transport in high-risk pregnancy | Component One: 1974<br>Component Two: 1978 | Time trends between 1973 and 1984 |
| Gale et al. (2012) | N/A | • Department of Health report issuing recommendations to reorganize neonatal services into clinical networks<br>• Reorganization of neonatal specialist care services into managed clinical networks | 2003 | Pretest: September 1, 1998 to August 31, 2000 |

| Study | Comparison Group | Intervention | Intervention Implementation | Study Period |
|---|---|---|---|---|
| | | | | Posttest: January 1, 2009 to December 31, 2010 |
| Hall et al. (2010) | N/A | • 2003: Arkansas ANGELS<br>  ○ Development of consensus practice guidelines<br>  ○ Weekly telemedicine conferences on obstetric topics<br>  ○ 24/7 call center at UAMS<br>  ▪ Provided provider consultations and arranged maternal transport<br>  ▪ Allowed calls from women concerned with pregnancy complications<br>• 2004: Weekly educational conferences: Pediatric Physician Leaning and Collaborative Education (Peds PLACE)<br>• 2004: Telenursery: Establishment of TM network at around 40 rural hospitals and other local health agencies (includes 15 Telenursery units) | Component one: 2003<br>Component two: 2004 | Pretest: 2001 to 2002<br>Posttest: April 2003 to 2004 |
| Hein (1980) | N/A | • Regionalization focused on increasing VLBW births in level II and level III hospitals<br>• 1970: Great Plains Perinatal Organization formed (includes six Midwestern states)<br>• 1973: Iowa's Perinatal Program established with focus on strengthening existing services<br>• 1973-1974: Needs assessment of hospitals<br>• Statewide outreach education coordinated by perinatal program<br>• Improvement of existing services in level I and II centers with emphasis on screening and referral of patients in need of higher level of care<br>• Level III hospital accepts responsibility for all patients<br>• Statewide transfer capabilities developed and coordinated by level III hospital | Component One: 1970<br>Component Two: 1973-74 | Pretest: 1972<br>Posttest: 1978 |
| Hein & Burmeister (1986) | N/A | • Regionalization focused on increasing VLBW births in level II and level III hospitals<br>• 1970: Great Plains Perinatal Organization formed (includes six Midwestern states)<br>• 1973: Iowa's Perinatal Program established with focus on strengthening existing services<br>• 1973-1974: Needs assessment of hospitals<br>• Statewide outreach education coordinated by perinatal program<br>• Improvement of existing services in level I and II centers with emphasis on screening and referral of patients in need of higher level of care<br>• Level III hospital accepts responsibility for all patients<br>• Statewide transfer capabilities developed and coordinated by level III hospital<br>• Funded by Federal block grant, state appropriation, and March of Dimes Grant | Component One: 1970<br>Component Two: 1973-74 | Pretest: 1972<br>Posttest: 1982 |

| Study | Comparison Group | Intervention | Intervention Implementation | Study Period |
|---|---|---|---|---|
| Hoekstra et al. (1981) | N/A | • Establishment of contractual relationship between level II and level III hospital<br>o Patients guaranteed immediate/ emergency consultation by subspecialists at level III hospital<br>o In-utero transfer of mothers delivering at <34 weeks or expected to deliver infants requiring intensive care<br>o Medical staff privileges transferred with patient admitted to level III hospital<br>o Level II hospital nurses provided training by level III hospital<br>o Shared maintenance of skills and orientation of new staff by level II and III<br>o Every delivery and nursery stay was peer-reviewed prior to patient discharge; discussed in educational conferences which were a quality control method<br>o Medical and nursing staff from level III served in consultative/ advisory roles to level II administration and on a variety of medical staff committees | April 1, 1979 | Pretest: 1978<br>Posttest: 1980 |
| Kim et al. (2013) | N/A | • Telemedicine (TM) Outreach Utilizing Collaborative Health-care (TOUCH) Program, a collaboration between UAMS tertiary center and the Centers for Medicare and Medicaid services<br>o Nine obstetric and nursery sites designated as TM hospitals based on large birth volume<br>• Sites educated about contacting Arkansas ANGELS call center<br>• TM support provided by previously established components including:<br>o Twice weekly TM census rounds by UAMS faculty: staff communicated their census, space for back-transfer of infants, anticipated deliveries with problems, and need for consult. Level III hospital faculty evaluated patient need for referral to a higher level of care.<br>o Continuous TM consultations through Arkansas ANGELS call center.<br>o Education through peer-reviewed treatment guidelines.<br>o Three times weekly interactive video education conferences for obstetrics and pediatrics (including Peds PLACE)<br>o TM social support (e.g., introducing caregivers from level III hospital to parents) | March to June 2009 | Pretest: July 2008- March 2009<br>Posttest: July 2009- March 2010 |
| Lessaris et al. (2002) | N/A | • Statewide program providing financial incentive via increased reimbursement for prenatal care of Medicaid patients<br>• Changes in third-party reimbursement emphasizing cost-reduction | January 1995 to December 1996 | Pretest: August 1990 to July 1992<br>Posttest: January 1995 to December 1996 |
| Lui et al. (2006) | N/A | • 1991: New South Wales Pregnancy and Newborn Services Network established<br>• 1992: Electronic NICU bed-state bulletin board to facilitate transfer | Component one: 1991<br>Component two: 1992<br>Component three: 1995 | Pretest: Jan. 1992 to June 1995<br>Posttest: Jan. 1997 to Dec. 2002 |

| Study | Comparison Group | Intervention | Intervention Implementation | Study Period |
|---|---|---|---|---|
| | | • 1995: Perinatal Advice Line established: statewide fetal/maternal specialist telephone service to assist community hospital obstetricians; encourages, coordinates, and optimizes maternal transfer to tertiary centers | | |
| McCormick et al. (1985)[1] | Eight comparison regions in the US | • Funding from Robert Wood Johnson Foundation to promote coordinated perinatal care systems<br>• Elements of regionalization were specified and local programs tailored their efforts to their needs<br>o Screening of all pregnant women for early identification of high-risk pregnancies<br>o Establishment of hospital level classification systems<br>o Upgraded services within all participating institutions<br>o Establishment of systems of communication and consultation<br>o Establishment of high-risk maternal transport<br>o Continuing education for health professionals | 1975 | Pretest: 1970-71<br>Intervention: 1974-75<br>Posttest: 1978-79 |
| Nugent (1982) | N/A | • 1972: Task Force on Maternal and Infant Health established; recommended regionalization of perinatal care through a set of principles<br>• 1974: State Regionalized Perinatal Care Program established by House Bill 1240 with a $500,000 appropriation<br>• Statewide Perinatal Council established for advising purposes<br>• State divided into perinatal regions with regional committees<br>• Needs assessment of local sites by regional committees. Regions submitted plans to statewide Perinatal Council<br>• Continued growth of funding through fiscal year 1978-79<br>o Reimbursed level III hospitals for intensive care of neonates; used for improvements in equipment and staffing of level III centers, professional education, and development of high risk clinics | Component one: 1972<br>Component two: 1974<br>Component three: 1978-79 | Period One: 1969-73<br>Period Two: 1972-76<br>Period Three: 1975-79<br>Period Four: 1979 |
| Powers & McGill (1987) | N/A | • Service and education responsibilities assigned to state-designated tertiary centers<br>• State divided into perinatal regions | 1974 | All years between 1973 and 1983 |
| The VICSG (1991) | N/A | • Mid-1970s: Educational efforts to improve early identification of impending ELBW (< 1000 gm) birth and transfer in utero to level III hospitals<br>• 1980: Increasing educational efforts after results of first cohort of infants released | Component one: mid-1970s<br>Component two: 1980 | Pretest: 1979-80<br>Posttest: 1985-87 |
| Tomich & Anderson (1990) | N/A | • Maternal transport service established<br>• Outreach educational program providing seminars for community hospitals<br>• Renovation of labor and delivery unit, construction of an obstetric intensive care unit, and expansion of NICU at level III center<br>• Administrative and financial support to allow level III hospital to hire additional staff and purchase equipment to provide care in the newly renovated areas | 1981 | Time trends between 1979 and 1986 |

| Study | Comparison Group | Intervention | Intervention Implementation | Study Period |
|---|---|---|---|---|
| | | • Additional faculty were recruited for Departments of Obstetrics and Gynecology and Pediatrics | | |
| Vendittelli et al. (2012) | N/A | • Clinical practice guidelines on the delivery of LBW babies emphasized that infants weighing less than 1500 gm at birth should be born in a level III unit and that maternity units should work in networks | 1998 | Time trends between 1994 and 2006 |
| Warner et al. (2002) | N/A | • Education of neonatal, obstetrical, and nursing medical staff<br>• Streamlining medical staff privileges and rotating staff between facilities<br>• Quality assurance review of transport numbers and individual case review with feedback<br>• Neonatal back-transport systems through on-call system | 1998 | Pretest: 1996 and 1997<br>Posttest: 1999 and 2000 |

[1] Additional information regarding the intervention components of this study were obtained from the report by The Robert Wood Johnson Foundation (1985)[41]

**Table 6. Intervention Components.**

| Study | Patient | | Hospital | | | | POPULATION-BASED SYSTEMS | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Inter-Hospital Systems | | | | | | | State | | | | | National | | |
| | Transition assistance | Access to provider through hotline | Development/ Improvement of services | Continuing education of hospital providers | Needs assessment | Peer-review of provider decisions | Maternal/ In-utero transport systems | Neonatal back-transport systems | Consultation systems | Telemedicine systems | Agreement for Level III hospital to accept all patients | Follow-up given on transferred patients | Medical staff integration (e.g., rotation between facilities, changes in privileges) | Policy/ Guidelines | Funding support | Perinatal committees/ councils | Increased reimbursement | NICU bed registry/ electronic bulletin board | Policy/ Guidelines | Reorganization of neonatal services |
| **HOSPITAL ONLY (n=2)** | | | | | | | | | | | | | | | | | | | | | |
| Cowett et al. (1986) | | | X | | | | | | | | | | | | | | | | | | |
| The VICSG (1991) | | | | X | | | | | | | | | | | | | | | | | |
| **POPULATION-BASED SYSTEMS (n=4)** | | | | | | | | | | | | | | | | | | | | | |
| Gale et al. (2012) | | | | | | | | | | | | | | | | | | | | | X |
| Lessaris et al. (2002) | | | | | | | | | | | | | | | | | X | | | | |
| Lui et al. (2006) | | | | | | | X | | X | | | | | | | X | | X | | | |
| Vendittelli et al. (2012) | | | | | | | | | | | | | | | | | | | X | | |
| **HOSPITAL + POPULATION-BASED SYSTEMS (n=10)** | | | | | | | | | | | | | | | | | | | | | |
| Bowes (1981) | | | | X | | | | | | | | | | X | X | X | | | | | |
| Campbell et al. (1991) | | | | X | | | X | | | | | X | | | | X | | X | | | |
| Hein (1980) | | | X | X | X | | X | | | | X | | | | | X | | | | | |
| Hein & Burmeister (1986) | | | X | X | X | | X | | | | X | | | | X | X | | | | | |
| Hoekstra et al. (1981) | | | | X | | X | X | | X | | X | | X | | | | | | | | |
| McCormick et al. (1985)[1] | | | X | X | | | X | | X | | | | | X | X | | | | | | |
| Nugent (1982) | | | X | X | X | | | | | | | | | X | X | X | X | | | | |
| Powers & McGill (1987) | | | | X | | | | | | | | | | X | | | | | | | |
| Tomich & Anderson (1990) | | | X | X | | | X | | | | | | | | | | | | | | |
| Warner et al. (2002) | | | | X | | X | | X | | | | | X | | | | | | | | |
| **PATIENT + HOSPITAL + POPULATION-BASED SYSTEMS[2] (n=3)** | | | | | | | | | | | | | | | | | | | | | |
| Bronstein et al. (2011) | | X | | X | | | X | | X | X | | | | X | | | | | | | |

| Study | Patient | | | Hospital | | | POPULATION-BASED SYSTEMS | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Inter-Hospital Systems | | | | | | | State | | | | | National | | |
| | Transition assistance | Access to provider through hotline | Development/ Improvement of services | Continuing education of hospital providers | Needs assessment | Peer-review of provider decisions | Maternal/ In-utero transport systems | Neonatal back-transport systems | Consultation systems | Telemedicine systems | Agreement for Level III hospital to accept all patients | Follow-up given on transferred patients | Medical staff integration (e.g., rotation between facilities, changes in privileges) | Policy/ Guidelines | Funding support | Perinatal committees/ councils | Increased reimbursement | NICU bed registry/ electronic bulletin board | Policy/ Guidelines | Reorganization of neonatal services |
| Hall et al. (2010) | | **X** | | **X** | | | **X** | | **X** | **X** | | | | **X** | | | | | | |
| Kim et al. (2013) | **X** | | | **X** | | | | **X** | **X** | **X** | | | | | | | | | | |

[1] Additional information regarding the intervention components of this study were obtained from the report by The Robert Wood Johnson Foundation (1985)[41]

[2] All three studies in this category are based on interventions conducted in Arkansas. Bronstein et al. (2011) and Hall et al. (2010) are addressing the same intervention but with different infants (<35 GA vs. <2500 gm). Kim et al. adds additional components to the intervention that are mainly focused on telemedicine.

**Table 7. Study Results.**

| Study | Results |
|---|---|
| Bowes (1981) | • The proportion of VLBW births among total births in each hospital level shifted between the pretest and posttest period. In level III hospitals, the proportion of VLBW births among total births rose from 2.8% to 4.8% ($p<0.05$).[1] In level II hospitals, the proportion of VLBW births among total births stayed the same (1.9%). In level I hospitals, there was a decrease from 1.6% to 1.1% of total births. |
| Bronstein et al. (2011) | <u>Any hospital with NICU:</u><br>• Although the change in percent of infants <35 weeks GA delivered at any hospital with NICU was statistically significant ($p<0.01$), the early increases in delivery seen in these hospitals after intervention in 2003 were lost after further follow-up. Over the study period, the percent of infants <35 weeks GA delivered at any hospital with NICU increased from 37.7% before intervention to a high of 44.1% in the year after intervention then subsequently decreased to 39.1% by then end of the follow-up period.<br>• No ANGELS intervention components were statistically significantly associated with delivery at any NICU hospital ($p>0.05$).<br><u>UAMS (tertiary center)</u>:<br>• Although the change in percent of infants <35 weeks GA delivered at UAMS was statistically significant ($p<0.001$), the early gains seen in percent delivered in the tertiary center appeared to be lost after further follow-up. Over the study period, the percent of infants <35 weeks GA delivered at UAMS tertiary center increased from 20.6% before intervention to a high of 27.3% in in the year after intervention then subsequently decreased to 19.6% by the end of the follow-up period.<br>• Women living in counties with hospitals that participated in teleconferences on high-risk obstetrics with University of Arkansas for Medical Science (UAMS; an ANGELS program component) were more likely to deliver at UAMS (odds ratio (OR): 1.64, 95%; CI: 1.17 to 2.30; $p=0.004$). No other ANGELS program component was statistically significantly associated with an increased likelihood of delivery at UAMS ($p>0.05$). |
| Campbell et al. (1991) | • Among all women admitted to level I or II hospitals, the percentage of maternal transfer to level III hospitals increased from 2.2% of all admitted women (262 women) to 2.8% ($p<0.003$) after the intervention.<br>• Among all women admitted to level I or II hospitals, maternal transfer of those with labor or threatened preterm labor before 37 weeks gestation to level III hospitals increased by 38% from 0.72% of all admitted women to 0.99% after intervention ($p=0.024$).<br>• Among all infants born at 500-1499 gm, there was a statistically significant change in distribution of the number born in level III hospitals after intervention ($p<0.001$)[1]. |
| Cowett et al. (1986) | • Among total births at the level III hospital, the percentage that were VLBW increased from 6.7% before intervention to 8.7% after intervention ($p<0.001$).<br>• The number of maternal transports to the level III hospital increased from 65 before intervention to 280 after intervention. This was accompanied by a corresponding increase in number of infants admitted to the NICU who were born to transferred women from 43 before intervention to 201 after intervention, suggesting some of the increase in maternal transfer was due to anticipated neonatal care needs. The authors do not comment on statistical significance of this result. |
| Gale et al. (2012) | • Among all infants born at $27^{+0}$ to $28^{+6}$ weeks GA, there was an increase in births at hospitals with the highest category of neonatal intensive care days (≥2000 days) from 18% to 49% (OR: 4.30, 95% CI: 3.83 to 4.82, $p<0.001$). |
| Hall et al. (2010) | <u>All LBW</u>:<br>• After the intervention, the case mix-adjusted probability of UAMS tertiary center delivery increased by 7.2% ($p<0.05$) among all LBW infants.<br>• After the intervention, the percentage of non-NICU hospital births among all LBW births was over 50% and was not significantly different than before intervention (p-value not indicated). |

| Study | Results |
|---|---|
| | • Among all LBW infants, there was little change in birth location distribution after intervention. The percentage born in community hospitals with NICU decreased slightly from 30.1% to 28.8%. The percentage born in UAMS tertiary center was around 18% both before and after the intervention. The authors do not comment on statistical significance of these results.<br>ELBW:<br>• Among all ELBW infants, there was little change in the birth location distribution. Of all ELBW infants, about 42% were born at UAMS tertiary center both before and after intervention. The percentage born in community hospitals with NICU decreased slightly from 35.3% to 30.7%. Data was not presented for births in non-NICU hospitals. The authors do not comment on statistical significance of these results.<br>ELBW subgroup:<br>• After intervention, the case mix-adjusted probability of UAMS tertiary center delivery increased from 27.6% to 34.5% ($p<0.01$) among ELBW births to mothers residing more than 80 miles from UAMS.<br>• Among ELBW infants born to mothers residing more than 80 miles from UAMS, there were some changes in birth location distribution. Of these infants, the percentage born in UAMS tertiary center increased from 40.7% to 46.8% after intervention. The percentage born in community hospital with NICU decreased from 26.8% to 17.5%. However, the percentage of non-NICU hospital births among this group increased from 32.5% to 35.7%. The authors do not comment on the statistical significance of these results. |
| Hein (1980) | • The intervention in Iowa focused on increasing both level III and level II VLBW births due to population density concerns in Iowa.<br>• Among all VLBW infants, there were changes in the birth location distribution. Of these infants, there was a statistically significant increase in percentage born in level III hospitals from 6.7% to 22.6% ($p<0.05$)[1] and an increase in births in level II hospitals from 26.9% to 35.6%. The percentage born in level I centers decreased from 68.2% to 41.8%. |
| Hein & Burmeister (1986) | • The intervention in Iowa focused on increasing both level III and level II VLBW births due to population density concerns in Iowa.<br>• Among all VLBW infants, there was a statistically significant change in the distribution of VLBW births ($p<0.001$). Of these infants, there was an increase in percentage born in level III hospitals from 6.7% to 35.3% and an increase in level II hospitals from 30.6% to 42.9%. The percentage born in level I centers decreased from 62.7% to 21.8%. |
| Hoekstra et al. (1981) | • After the intervention, there was a statistically significant decrease in the number of VLBW infants born in a level II hospital ($p<0.01$). |
| Kim et al. (2013) | • Among all VLBW births, there was a change in the birth location distribution. Of these infants, the percentage born in non-NICU hospitals with telemedicine intervention (targeted hospitals) statistically significantly decreased from 13.05% to 7.03% ($p=0.0099$).<br>• Changes in other hospital levels (including UAMS tertiary center) were not statistically significant. |
| Lessaris et al. (2002) | • The overall birth location distribution of VLBW births did not significantly change after intervention ($p=0.375$). |
| Lui et al. (2006) | • Among all infants born at 23 to 28 weeks GA, there was a statistically significant decrease in the percentage of non-tertiary hospital births from 30.1% to 24.6% ($p<0.001$).<br>  ○ This decrease was mostly driven by a large decrease among births at 23 to 24 weeks GA from 50.8% to 37.6% ($p<0.001$).<br>  ○ The decrease among all births at 25 to 26 and 27 to 28 weeks was not statistically significant ($p= 0.075$ and $p= 0.194$, respectively). |
| McCormick et al. (1985) | • Among all VLBW infants in intervention regions, there was a shift towards increasing births in tertiary centers from 35.72% in the pretest period to 47.3% at the time of intervention to 59.4% in the posttest period.<br>• Among all VLBW infants in comparison regions, there was also a shift towards increasing births in tertiary centers from 29.67% in the pre-test period to 34.2% at the time of intervention to 47.19% in the posttest period. |

| Study | Results |
|---|---|
| | • The authors do not comment on the statistical significance of these results. However, the authors do note that the difference in the rate of centralization of births in tertiary centers was not "strikingly greater" in the intervention regions as compared with the comparison regions. |
| Nugent (1982) | • Among all VLBW infants, there was a change in birth location distribution. Of these infants, the percentage born in level III hospitals increased from 25.7% in period one to 46.8% in period four. The percentage born in level II hospitals decreased from 41.7% to 36% and the percentage born in level I also decreased from 32.6% to 17.2%. The authors do not comment on the statistical significance of these results. |
| Powers & McGill (1987) | • During all but one of nine post-intervention years, the percentage of regional VLBW births delivered in level III hospitals was statistically significantly higher than what would have been expected had it been the same as the percentage of all regional births delivered at level III hospitals ($p<0.001$). This suggests that VLBW births compromise a larger percentage of total births at level III hospitals than would be expected if they followed the same birth location distribution as all infants in the region. |
| The VICSG (1991) | • Among all ELBW infants, the percentage of non-level III hospital births statistically significantly decreased after intervention from 30.2% to 23.0% (OR: 0.69, 95% CI: 0.51 to 0.93, $p=0.02$). |
| Tomich & Anderson (1990) | • There was a change in the proportion of VLBW births out of total births at tertiary and outlying hospitals. Of total births at the tertiary center, VLBW infants represented a statistically significantly higher percentage after intervention than before (9.9% and 3.9% of total births, respectively; $p<0.001$). There was only a slight decrease in VLBW births as a proportion of total births in outlying hospitals from 1.39% to 1.17%. The authors do not comment of the statistical significance of that result.<br>• There was a rapid increase in the number of maternal transfers for all reasons from 97 per year pre-intervention to around 350 per year post-intervention. The authors do not comment on statistical significance of this result. |
| Vendittelli et al. (2012) | • Among all VLBW births, the percentage of level III births statistically significantly changed over the study period ($p<0.0001$). However, the percentage was increasing before intervention and through one year post-intervention, then subsequently decreased through the end of the follow-up period.<br>• The author suggests that the intervention did not have a significant effect on the percentage of VLBW births in level III hospitals[2]. |
| Warner et al. (2002) | • There was a significant decrease of 63% in the number of VLBW births at level II hospital after intervention (p-value and statistical test not indicated).<br>• The annual number of maternal transports to level III hospital increased 258% after intervention from an average of 38 per year to 98. The authors do not comment on statistical significance of this result. |

[1] Statistical significance of this result was calculated by authors (EP & DS).
[2] Based on author (EP) correspondence with F. Vendittelli (personal communication, August 24, 2016).

**Table 8. Summary of Study Results.**

| Study | VLBW place of delivery | Maternal transport[3] |
|---|---|---|
| **HOSPITAL ONLY** | | |
| Cowett et al. (1986)[4] | + | + |
| The VICSG (1991) | + | |
| **POPULATION-BASED SYSTEMS ONLY** | | |
| Gale et al. (2012) | + | |
| Lessaris et al. (2002) | ns | |
| Lui et al. (2006) | + overall<br>+ for 23 to 24 weeks GA<br>ns for 25 to 26 and 27 to 28 weeks GA | |
| Vendittelli et al. (2012)[5] | ns | |
| **HOSPITAL + POPULATION-BASED SYSTEMS** | | |
| Bowes (1981)[6] | + | |
| Campbell et al. (1991)[6] | + | + |
| Hein (1980)[6,7] | + | |
| Hein & Burmeister (1986)[7] | + | |
| Hoekstra et al. (1981)[8] | + | |
| McCormick et al. (1985) | ns | |
| Nugent (1982)[9] | + | |
| Powers & McGill (1987) | + | |
| Tomich & Anderson (1990)[4] | + | + |
| Warner et al. (2002)[4, 10] | + | + |
| **PATIENT + HOSPITAL + POPULATION-BASED SYSTEMS[11]** | | |
| Bronstein et al. (2011) | + early findings not sustained long-term<br>+ for counties participating in teleconferences | |
| Hall et al. (2010)[12] | + for LBW<br>+ for ELBW subgroup | |
| Kim et al. (2013) | ns | |

[1] With regards to the symbols, "+" refers to a statistically significant favorable outcome on a p=0.05 level; "–"refers to a statistically significant unfavorable outcome on a p=0.05 level; "ns" refers to a non-significant outcome; and cells with a gray shade indicate that the outcome was not measured or reported.
[2]This outcome is focused on increasing VLBW births in level III hospitals.
[3] Includes changes in maternal/ in-utero transport patterns. Favorable outcomes would include increasing maternal transport from lower level hospitals to level III hospitals.
[4] Maternal transport outcome includes results favorable for NPM 3, but no results of statistical testing are reported.
[5] VLBW place of delivery outcome symbol based on author email correspondence with F. Vendittelli (personal communication, August 24, 2016).
[6] Statistical significance of VLBW place of delivery outcome results calculated by authors (EP & DS).
[7] VLBW place of delivery outcome focused on increasing births in both level II and level III hospitals due to Iowa population density.
[8] VLBW place of delivery outcome focused on decreasing births in level II hospitals.
[9] VLBW place of delivery outcome results show large favorable changes but no results of statistical testing are reported.
[10] VLBW place of delivery outcome focused on decreasing births in level II hospitals accompanied by increases in maternal transport to level III.
[11] All three studies in this category are based on interventions conducted in Arkansas. Bronstein et al. (2011) and Hall et al. (2010) are addressing the same intervention but with different infants (<35 GA vs. <2500 gm). Kim et al. adds additional components to the intervention that are mainly focused on telemedicine.
[12] VLBW place of delivery outcome is after adjustment for case-mix (birth weight and gestational age).

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