Neonatal transport In developing country settings: a systematic review

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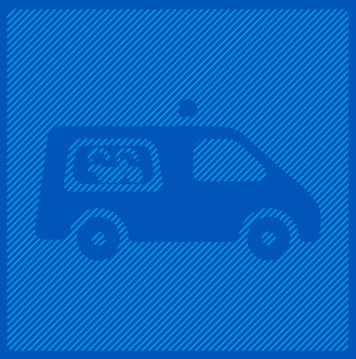

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Av. Brasil 2697 - Ap.4
Montevideo - Uruguay CP 11300
Ph.: + 598-2 487-2929; + 598-2 706-3020
www.paho.org/clap/

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Coordination:

Suzanne Serruya
Pablo Durán

Authors:

Susan Niermeyer
Gretchen Domek

External Review Committee:

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Abstract

Background: Reduction in neonatal mortality is central to achieving global child survival targets in the coming decades. Efforts to prevent the primary causes of neonatal death (prematurity, asphyxia, severe infections, congenital anomalies) must be complemented by development of systems to care for sick newborns, including safe neonatal transport.

Objectives: This systematic review identifies and analyzes the evidence on neonatal transport in developing countries in order to highlight important conclusions and gaps in knowledge in preparation for development of clinical guidelines and practical tools to support safe neonatal transport.

Methods: The electronic search strategy included terms related to transport, access, and referral of neonates. Data sources included MEDLINE, Embase, CINAHL, Web of Science, the Cochrane Library, LILACS, SciELO, and African Index Medicus. Eligible studies utilized a randomized, quasi-randomized or non-randomized prospective design with a comparison group. Cross-sectional, caseseries, case-control, or cohort studies that identified modifiable outcomes were included when there were defined comparison groups or comparison with established standards or guidelines. The review focused on transport of infants with an age 28 days or less from the community or a primary care facility to a center with specialty neonatal care, as well as inter-facility patient transfers between two neonatal specialty care centers and intra-facility patient transfers to/from a neonatal specialty care unit. Articles were evaluated for strength of study design, selection bias, control for confounders, and data collection methods.

Results: Forty studies met inclusion criteria. There were no randomized controlled trials and five quasi-experimental pre/post studies; most studies were of moderate to weak quality. Fourteen studies examined physiologic stability during transport and identified potentially modifiable risk factors associated with clinical deterioration and mortality or differential outcomes between inborn and outborn (transported) neonates. Six studies compared management of neonatal transports with norms for performance or formal regional guidelines. Six studies examined the effect of team training/composition on knowledge and skills, physiologic indicators of stability, and/or mortality. Three studies reported trails of equipment (transport carriers or incubator). Eleven studies considered the role of neonatal transport in providing access to the health system.

Conclusions and implications: Evidence supported the need for establishment of neonatal transport services to provide equitable and widespread access to high-quality care for infants in the first month of life. Improvement in the outcome of transported neonates can be readily achieved by focusing on issues of basic physiological stability. Specific training in patient assessment and management can improve outcome, but must be accompanied by necessary systems changes, including proper equipment, norms, and oversight.

Abbreviations

AAP	American Academy of Pediatrics
CFT	capillary filling time
CLD	chronic lung disease
EMS	emergency medical service
EPHP	Effective Public Health Practice Project
GA	gestational age
HIE	hypoxic-ischemic encephalopathy
IV	intravenous
nCPAP	nasal continuous positive airflow pressure
NICU	neonatal intensive care unit
NR	not reported
OR	odds ratio
RR	risk ratio
SIMV	synchronized intermittent mandatory ventilation
SNAP-II	Score for Neonatal Acute Physiology II
SNAPPE-II	Score for Neonatal Acute Physiology Perinatal Extension-II
S.T.A.B.L.E	Sugar, Temperature, Airway, Blood pressure, Lab work, and Emotional support (training program)
TBA	traditional birth attendant
TOPS	Temperature, Oxygenation, Perfusion, and blood Sugar
TRIPS	Transport Risk Index of Physiologic Stability
TTN	transient tachypnea of the newborn
VLBW	very low birth weight

Introduction

Aims and rationale

Mortality occurring in the neonatal period, defined as the first 28 days of life, accounts for over 40% of deaths in children under the age of 5 years globally, according to *The Millennium Development Goals Report 2013* (United Nations 2013). Leading causes of mortality in neonates include prematurity, asphyxia, severe infections, and congenital anomalies. The majority of births in developing countries take place in rural settings, often in the home, and with providers (such as traditional birth attendants) with limited formal training and minimal equipment. Additionally, specialty neonatal care facilities are often few in number, transport modes are limited, and transportation routes are difficult and time-consuming. Many neonatal deaths could be avoided and morbidity reduced with the ability to safely transfer a sick newborn to a health facility with a higher level of care. In order to improve the procedures related to neonatal transport and to improve the quality of care under these critical conditions, it is necessary to provide technical guidelines supported by scientific evidence to the organizations, facilities, and health care professionals in charge of setting health system priorities and policies surrounding the transport of neonates.

The specific aim of this review is to analyze the evidence and experience on neonatal transport in developing countries in order to establish a practical guideline that would help those responsible for coordinating the transport of neonates to perform it in the most effective manner and with the highest standards of quality.

Objectives

The overall objective is to perform an assessment of referral systems in developing countries to transfer neonates to higher levels of care in a timely and effective manner. The specific objectives include:

1. To perform a review of the scientific evidence on neonatal transport, focusing on the assessment of basic conditions, stabilization, requirements for a quality transport (equipment, human resources, etc.), and differences or specificities depending on the transport media.
2. To analyze the evidence identified.
3. To consolidate the results, identifying the main observations and also those critical aspects for which there is no clear evidence. The document will be the background for developing clinical guidelines to be used in health facilities.
4. To propose further steps in the design and validation of a clinical guideline and the practical tools to support safe neonatal transport.

Conceptual framework

The "three delays" model (Thaddeus and Maine, 1994) describes a conceptual framework for the factors and subsequent phases of delay that influence the timely accessibility of specialty care in obstetric emergencies and ultimately contribute to maternal deaths. The model has been adapted for analysis of obstetric referral interventions (Hussein 2012), perinatal deaths (Mbaruku 2009), and neonatal deaths (Waiswa 2010). We have adapted this conceptual framework for the phases of delay that affect transport and the timely arrival to specialty neonatal care. Such critical delays are a major contributing factor to neonatal mortality. These delays include: (I) delays in deciding to seek care for reasons that include socioeconomic and cultural factors, (II) delays in reaching an appropriate medical facility, and (III) delays in receiving adequate care once at an appropriate medical facility due to poorly staffed, equipped, and managed facilities. For the purpose of this review, the interventions that we examine will address primarily Phase II delays that pertain to the accessibility of appropriate health services. The issues confronted in Phase II include the ability to reach an appropriate facility, the time spent to reach an appropriate facility, and the morbidity/mortality associated with reaching the facility. Specific factors considered include the distribution and location of appropriate medical facilities and health care providers, established referral patterns, travel distances and times, availability of transportation and transportation routes, costs of travel, and availability/quality of medical treatment during transport. These delays are most common and often severe in developing countries, especially in rural settings, where specialty medical facilities, trained health care providers, and modes of transportation are limited. Phase III relates to delay or compromised quality of care of transported neonates at the medical facility. The issues considered in Phase III that are relevant to this review include morbidity associated with poor communication before/upon arrival at the medical facility and morbidity associated with intra-facility transport of neonates for diagnostic/ surgical procedures.

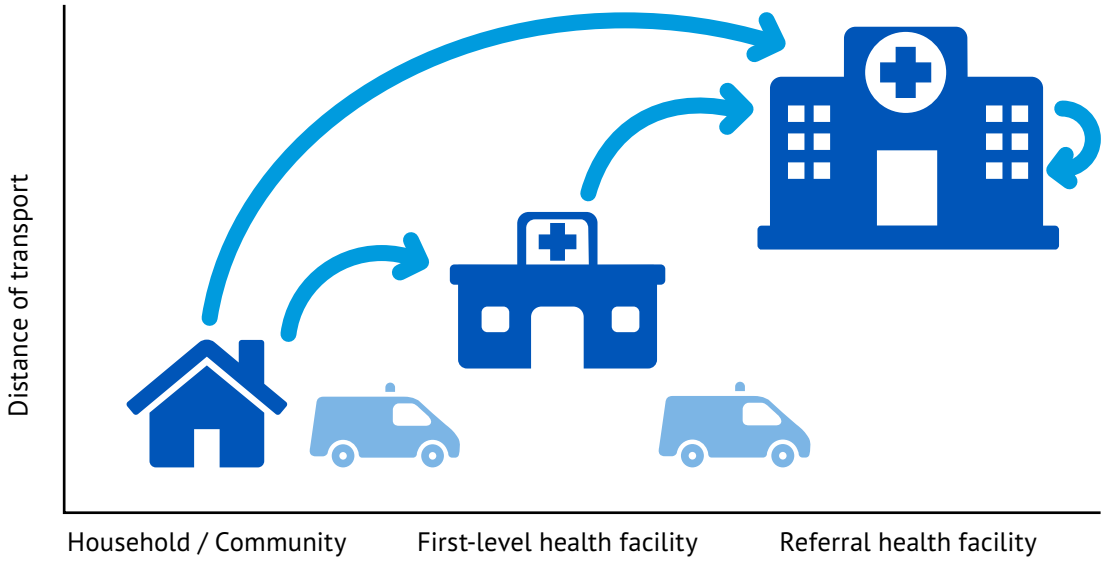


Figure 1. Conceptual model of neonatal transport. Neonatal transport most often occurs from a first-level health facility to a referral center; however, transport may occur from the community to a health facility or within a facility (intra-facility transport).

Methods

Protocol and registration

A review protocol (available upon request from the authors) was created prospectively to conform with the objectives of the systematic review. Methods followed the PRISMA 2009 Checklist (Appendix 1). The systematic review was not publicly registered. Because of the absence of randomized controlled trials and controlled clinical trials, meta-analysis was not undertaken.

Eligibility criteria

Participants

This review includes neonates, defined as newborn infants with a chronological age of 28 days or less irrespective of the postmenstrual age at birth, who are referred from the community or from a primary care facility to a center where specialty neonatal care is available. It will also include inter-facility patient transfers between two neonatal specialty care centers (e.g., for specialized services such as pediatric surgery or ventilation) and intra-facility patient transfers to/from a neonatal specialty care unit (e.g., from a neonatal intensive care unit to the operating room or an imaging facility). Exclusion criteria include pregnant and post-partum women referred for an obstetric complication or emergency and infants or children transferred or referred beyond the neonatal period.

Interventions and observations

All interventions to improve the emergency referral of infants during the neonatal period are relevant to this review. These may include, but are not limited to, interventions that provide training, communication, or incentives pertaining to neonatal referral or transport as well as interventions that improve already existing methods of transport, provide new methods or equipment for transport, improve physiologic stability and care during transport, enhance monitoring and assessment during transport, create new referral facilities, or improve linkages between referral levels. Cross-sectional, case series, case-control, or cohort studies that identified modifiable outcomes were included when there were defined comparison groups or comparison with established standards or guidelines for performance.

Outcome measures

Primary outcome measures for the review were neonatal morbidity and mortality. Morbidity includes physiologic factors such as thermal stability (hypothermia), glucose control (hypoglycemia), and oxygen saturation (hypoxia). Secondary outcome measures include factors such as travel time, referral rates, type of transportation, type/timing of communication, utilization of services, costs (direct and indirect), provider knowledge and skills, and the family's satisfaction with a service or intervention.

Settings

Studies included come from developing countries, limited to countries classified by the World Bank as low-income, lower-middle-income, and upper-middle-income economies (http://data.worldbank.org/about/country-classifications/country-and-lending-groups). Studies from developed countries are not included.

Study designs

Study designs eligible for inclusion in this review are randomized or quasi-randomized studies with a control or comparison group, non-randomized prospective studies with a comparison group, controlled before-after studies, and interrupted time series analyses of neonatal emergency referral systems. Cross-sectional, case series, case-control, or cohort studies that identified modifiable outcomes were included when there were defined comparison groups or comparison with established standards or guidelines for performance. Studies without a comparison group were excluded, as were editorials, comments, letters, historical articles, and case reports.

Identification of relevant studies

Search strategy

The electronic search strategy was based on terms related to transport, access, and referral of neonates. The search strategy (Appendix 2) was run in MEDLINE on the Ovid platform. The search strategy was then adapted for Embase, CINAHL, Web of Science, and the Cochrane Library as well as LILACS, SciELO, and African Index Medicus. Reports and studies from the gray literature were also considered for relevance.

Searches were conducted between March and June 2013. Adaptation for other databases was accomplished by selecting appropriate subject heading or keywords from the respective thesauri; no date or language restrictions were employed. Electronic search citations were downloaded using EndNote X7 (Thompson Reuters). Reference lists from retrieved papers were screened. Non-indexed and gray literature was included.

Screening studies

Inclusion and exclusion criteria were applied successively to titles, abstracts, and full articles. Abstracts were obtained and reviewed for those titles that appeared to meet the specified inclusion criteria, and full articles were obtained and reviewed for those abstracts that appeared to meet the criteria or when information was insufficient to exclude articles based on title and abstract alone. The inclusion and exclusion criteria were then reapplied to the full reports by two separate reviewers in order to determine the articles included in the final review.

Data extraction, quality assessment, and analysis

Quality assessment was guided by the Effective Public Health Practice Project quality assessment tool for quantitative studies (EPHPP 2009). For non-randomized studies, the components rated were limited to estimates of selection bias, description of study design, confounders, data collection methods, and analyses. Two reviewers independently assigned quality scores and compared assessments. Uncertainties were resolved by arbitration with an independent third reviewer.

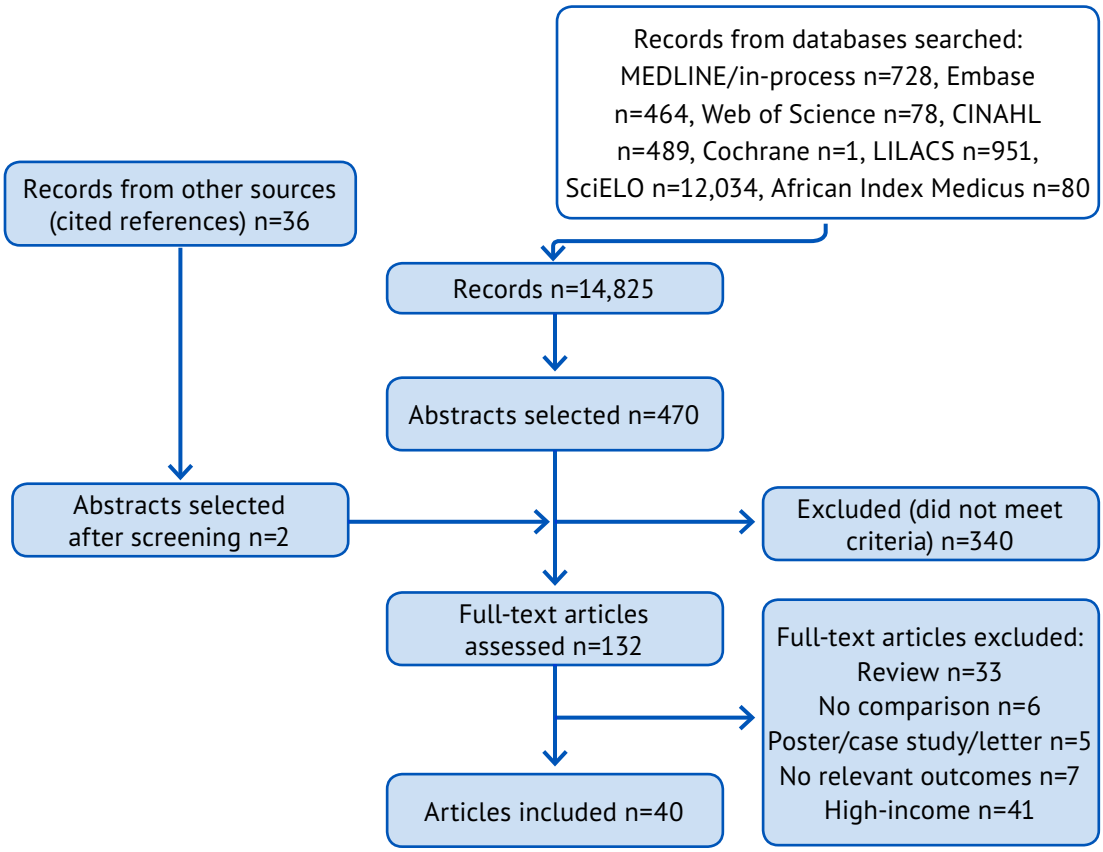
Synthesis of the studies began with categorization of the scope and intent of the studies and their outcomes. For each study a tabular summary entry was created that included author, year, and country; study design; setting (levels of care); participants; dates of study; comparison groups; outcomes; and conclusions/recommendations. In the absence of randomized controlled trials or a sufficient number of quasi-experimental studies, further analysis of size/direction of effect was not possible. Studies within each category were summarized in narrative fashion for their common themes and notable differences. The implications for development of guidelines for neonatal transport in developing countries were identified and discussed, gaps in the available evidence were highlighted, and directions for future research suggested.

Results and systematic review references

Study selection

Search results and study selection are summarized in Figure 2. Forty studies met inclusion criteria of having a defined comparison and measured outcomes. Complete citations are listed in the "References Included in the systematic review" section at the end of this chapter, begining on page 36 (reference citations for the other chapters of this book are given in the "General references" chapter, which begins on page 55).

Figure 2.



Study characteristics and quality assessment

Table 1, which is given on page 22, summarizes the quality assessment of the included studies. There were no randomized controlled trials of interventions related to neonatal transport. Five studies employed a quasi-experimental pre/post design around educational interventions or significant changes in health system structure. The majority of studies reported on prospective or retrospective cohorts, analysis of cross-sectional samples, or case series. Assessment of whether the participants in studies were representative of the target population and the extent to which missing data introduced selection bias was difficult because of lack of details on the conduct of studies. Data collection tools were described primarily in studies of physiological scoring systems for risk classification and comparisons with established guidelines for transport. Analyses were often limited to descriptive statistics on comparison groups and Chi-square or *t* tests to define differences in outcome. Logistic regression analysis was employed in a small number of studies.

Results of individual studies

Characteristics of included studies are summarized in Table 2, which begins on page 23. According to the conceptual framework for the systematic review, the studies focused on Phase II and Phase III delays, that is, respectively, reaching an appropriate medical facility and obtaining adequate and appropriate medical treatment. Studies relating to the processes, conditions of

clinical care, equipment, systems, and training of personnel directly involved in the activity of neonatal transport are presented in sections entitled: 1) "Transport Results physiology and care," 2) "Adherence to norms and guidelines," 3) "Team training and composition," and 4) "Equipment." A fifth section, entitled "Access/Health system," contains studies relating to the broader organization of neonatal transport within the health care system and issues of access to health care as impeded/facilitated by neonatal transport or modifications of the health structure. Active interventions focused on transport team training, application (during transport) of scoring tools for assessment of physiologic stability and prediction of mortality, and changes in health coverage or health services available at the population level.

Synthesis of results

1) Transport physiology and care

Fourteen prospective and retrospective cohort studies examined physiologic stability during transport and identified the potentially modifiable risk factors associated with clinical deterioration and mortality or differential outcomes between inborn and outborn (transported) neonates. Eleven of the studies identified hypothermia as a factor strongly associated with deterioration/mortality (Buch 2012, Goldsmit 2012, Lucas da Silva 2012, Mathur 2005, Mathur 2007, Sehgal 2001, Silveira 2003, Singh 1996, Vieira 2011a,b,c). Other risk factors associated with adverse outcomes included hyperthermia, hypoglycemia, poor perfusion, and length of time in transport. One study (Chung 2009) demonstrated a higher risk of chronic lung disease as a notable difference between transported very low birth weight (VLBW) preterm infants and matched inborn controls. Three studies (Goldsmit 2012, Lucas da Silva 2012, Mathur 2007) examined the utility of illness severity scores (SNAP-II, SNAPPE-II, TRIPS, TOPS) in assessment, triage, and prediction of mortality. One small study of intra-hospital transports (Carsi-Bocanegra 2001) found that high-, moderate-, and low-acuity patients could be transported safely with adequate technology and trained personnel. A series of three studies (Vieira 2011a,b,c) examined the clinical complications associated with intra-hospital transports and developed and validated a predictive score to identify neonates at risk of such complications.

Several studies documented the high percentage of transports accomplished by family members and the low proportion of transports performed by trained personnel with adequately equipped transport vehicles and appropriate communication surrounding the transport. Reported mortality rates for neonates after inter-facility transport were exceptionally high in several reports and often correlated with the degree of hypothermia. Even with well-trained and -equipped teams, the lack of specific expertise in respiratory care of infants was associated with higher rates of chronic lung disease.

2) Adherence to norms and guidelines

Six studies compared management of neonatal transports with norms for performance or formal regional guidelines. Four cohort studies (Albuqerque 2012, Hadley 2001, Mutlu 2011, Nakhshab 2010) described poor conformity with regional norms. The key deficiencies identified were: communication before and during transport, adequacy of the team and transport unit,

stabilization before transport, continuation of basic supportive care, equipment maintenance and function, and documentation of patient status. A case-control comparison of referred infants with and without hypoxic-ischemic encephalopathy (HIE) noted that only 11% of neonates were accompanied by a referral letter, and infants with HIE were no more likely to have a referral letter despite the central importance of such information to planning patient management and defining prognosis (Butt 2007). A case series of 15 transported neonates highlighted the disparity between provincial and private ambulance transfers, with lower quality of private inter-hospital transports (Roux 1989).

3) Team training and composition

Six studies examined the effect of team training on knowledge/skills and physiologic indicators of stability and the effect of team training/composition on physiologic indicators and mortality of transported neonates. In a series of three studies (Kumar PP 2008, 2010, 2011), care by a specially trained neonatal team was associated with improved physiologic stability, whether transport covered long or short distances. The third study in the series (Kumar PP 2011) again showed decreased complications of glucose and thermal control, hypoxia, and apnea among infants transported by a specialized team and reported that survival was significantly higher (96 vs. 89%) among those infants accompanied by the specialized team. Two before-and-after studies delivered the S.T.A.B.L.E. program to medical and paramedical transport personnel (Martinez Veronica 2011, Spector 2009), with improvement in physiological variables and equipment use as well as decreased mortality post-intervention in one study, but more limited improvement in thermal control only, without change in mortality in the other setting. A third before-and-after study (Chandy 2007) trained community and facility providers in the Delivery Life Support program as an extension of a trauma life support/ transport initiative and demonstrated improvement in knowledge, skills, confidence, and teamwork, but did not report infant outcomes.

4) Equipment

Three studies reported trials of transport carriers designed to provide thermoregulation for neonates. One study examined infant temperatures before and after transport in a commercially available styropor box (Gosavi 1998) and found that the environment prevented hypothermia during inter-facility transport between urban hospitals. Comparison of a custom-crafted insulated carrier with warm wraps showed improved temperature stability during short transfers between a neonatal care ward and the operating room (Joshi 2010). A comparison of premature infants cared for in a prototype non-electric incubator vs. a commercial incubator showed stable, equivalent vital signs in the two groups (Khodadadeh 2001); however, observations took place among non-distressed infants in the neonatal care unit.

5) Access/Health system

Eleven studies examined the role of neonatal transport in providing access to the health system. Five studies compared inborn and outborn (transported) neonates with respect to intermediate physiological outcomes and/or mortality (Araújo 2011, Dicko 2010, Enweronu-Laryea 2008, Kumar M 2002, Ndiaye 2003) and showed that outborn status was consistently associated with higher mortality. Improvements in neonatal intensive care unit (NICU)

facilities in one of these study areas resulted in increased survival of very low birth weight (VLBW) outborns, but a large increase in referrals of infants >2500 grams (Enweronu-Laryea 2008). Two studies utilized the Three Delay Model to analyze verbal and social autopsies(Upadhyay 2013, Waiswa 2010) and reported that half or more of overall mortality was due to Phase II and III delays. One before-and-after study (Lu 1999) documented the impact of implementation of national health insurance on transported neonates, including decreased mortality and discharge against medical advice. Another single study (Wang 1997) examined the effect of referral from obstetric clinics to either a district hospital or tertiary center and found higher mortality for all infants referred to the level II center and specifically for ventilated infants. Large-scale implementation of transport with a structured, specialized neonatal transport service resulted in reduction in early neonatal mortality rates in areas served by the dedicated team (Woodward 1997). Another before-and-after study of the implementation of a package of improvements in neonatal transport (Uslu 2011) showed decreased physiologic complications, improved Transport Risk Index of Physiologic Stability (TRIPS) scores, and greater compliance with guidelines in the post-intervention period.

Table 1. Quality assessment summary (EPHPP 2009) [1]

Author Year	Control of Selection bias	Strength of Study Design	Control for Confounders	Data Collect. Methods
Transport physiology and care				
Buch 2012	Weak	Moderate	Strong	Weak
Carsi-Bocanegra 2001	Weak	Weak	Weak	Weak
Chung 2009	Weak	Moderate	Strong	Weak
Goldsmit 2012	Moderate	Moderate	Strong	Strong
Karagol 2011	Moderate	Moderate	Weak	Weak
Lucas da Silva 2012	Moderate	Moderate	Strong	Strong
Mathur 2005	Weak	Moderate	Strong	Strong
Mathur 2007	Weak	Moderate	Weak	Weak
Sehgal 2001	Weak	Moderate	Strong	Weak
Silveira 2003	Weak	Moderate	Strong	Weak
Singh 1996	Weak	Moderate	Weak	Weak
Vieira 2011a	Weak	Moderate	Strong	Weak
Vieira 2011b	Weak	Moderate	Strong	Weak
Vieira 2011c	Weak	Moderate	Strong	Strong
Adherence to norms and guidelines				
Albuquerque 2012	Weak	Moderate	Weak	Weak
Butt 2007	Weak	Moderate	Weak	Weak
Hadley 2001	Moderate	Moderate	Weak	Weak
Mutlu 2011	Weak	Moderate	Weak	Weak
Nakshab 2010	Moderate	Moderate	Weak	Weak
Roux 1989	Weak	Weak	Weak	Weak
Team training and composition				
Chandy 2007	Weak	Moderate	Weak	Weak
Kumar PP 2008	Weak	Moderate	Weak	Weak
Kumar PP 2010	Weak	Moderate	Weak	Weak
Kumar PP 2011	Weak	Moderate	Weak	Weak
Martínez Verónica 2011	Moderate	Moderate	Weak	Weak
Spector 2009	Moderate	Moderate	Weak	Weak
Equipment				
Gosavi 1998	Weak	Moderate	Weak	Weak
Joshi 2010	Weak	Weak	Weak	Weak
Khodadadeh 2001	Weak	Moderate	Weak	Weak
Access/Health system				
Araújo 2011	Weak	Moderate	Weak	Weak
Dicko 2010	Weak	Moderate	Weak	Weak
Enweronu-Laryea 2008	Weak	Moderate	Weak	Weak
Kumar M 2002	Weak	Moderate	Weak	Moderate
Lu 1999	Moderate	Moderate	Weak	Weak
Ndiaye 2003	Moderate	Moderate	Weak	Weak
Upadhyay 2013	Moderate	Moderate	Weak	Moderate
Uslu 2011	Moderate	Moderate	Weak	Moderate
Waiswa 2010	Moderate	Moderate	Weak	Strong
Wang 1997	Weak	Moderate	Weak	Weak
Woodward 1997	Strong	Moderate	Weak	Weak

[1] Effective Public Health Practice Project (2009) http://www.ephpp.ca/Tools.html.

Table 2. Summary of characteristics of included studies

Author/Country	Study Design	Levels of Care	Participants	Dates of Study	Comparison	Results	Recommendations
Transport physiology and care							
Buch 2012 / India	Prospective cohort of referred neonates over 6 months	Transport from homes, primary health centers, public and private hospitals to a NICU	149 referred neonates (48 deceased, 51 survived, 50 left against medical advice)	8/2010-1/2011	Deceased and surviving neonates	Physiologic factors significantly associated with mortality included: -Hypothermia -CFT > 3 seconds -RR > 60/minute Only 26.8% of transports used an ambulance, 11.4% had an accompanying skilled attendant, and 33% sought advice regarding care during transport.	Mortality can be improved by promoting institutional deliveries, proper regionalization of newborn care, appropriate pre-referral stabilization, communication during transport, and adequate equipment and staff at the referral facility.
Carsi-Bocanegra 2001 / Mexico	Prospective cohort of transported neonates over 1 year	Intra-facility transport of NICU patients (i.e. for surgical and imaging procedures)	26 transported neonates (9 high risk, 11 medium risk, 6 low risk)	12/1998-12/1999	Complications during transport in high, medium, and low risk groups of neonates	No statistical differences in complications were found among risk groups.	Complications during intra-facility transport of NICU patients can be minimized with proper transport procedures.
Chung 2009 / Taiwan (China)	Case-control study of referred VLBW preterm neonates and matched inborn controls over 4 years	Inter-facility transports from hospitals to a NICU	68 VLBW neonates (34 inborn, 34 outborn)	1999-2003	Complications of prematurity in transported VLBW preterm neonates and matched inborn controls	Risk of CLD in the outborn group was 4.4-fold higher than in the inborn group.	Respiratory outcomes in transported neonates can be improved by including a respiratory therapist in the transport team and with the timely administration of surfactant.
Goldsmit 2012 / Argentina	Prospective cohort of referred neonates over 10 months	Inter-facility transport from various institutions to a NICU	160 referred neonates	7/2009-5/2010	Pre and post-transport TRIPS scores	Clinical deterioration was seen in 57% of transports, independent of patient characteristics, type or severity of their condition. Thermal and respiratory status showed most instability.	Newborn infants who are less critically ill still require the optimization of care during transport to prevent complications of hypothermia and hypoglycemia. Tools or scores to systematically measure the quality of transport (such as TRIPS) can be useful to audit and optimize neonatal transport services.

Author/Country	Study Design	Levels of Care	Participants	Dates of Study	Comparison	Results	Recommendations
Karagol 2011 / Turkey	Retrospective cohort of referred term neonates with TTN over 4 years	Transport from hospitals to a NICU	208 referred term neonates with TTN (105 transferred from within the city, 103 transferred from outside the city)	1/2005-12/2009	Illness variables of neonates transferred from within the city and outside the city	Transport from outside compared to within the city led to significantly worsened illness variables, including admission time to NICU (13.6 hours v. 6.6), intubations during transport (10 v. 3), respiratory support in NICU (nCPAP 42 v. 27; SIMV 26 v. 3), duration of antibiotic treatment (7.2 v. 5.5 days), presence of pulmonary air leak syndrome (20 v. 4), duration of hospitalization (8.4 v. 6.1 days), development of pneumothorax (20 v. 4), and blood gas parameters at admission.	Long-distance land-based transport in neonates with TTN increases the severity of illness and requires appropriate respiratory equipment and trained transport staff.
Lucas da Silva 2012 / Brazil	Prospective cohort of referred neonates over 3 years	Inter-facility transport from hospitals to a NICU	175 referred neonates	3-year period	TRIPS, SNAP-II, SNAPPE-II scores	TRIPS score at admission had good performance in predicting high-risk patients for 7-day mortality and was similar to SNAP-II and SNAPPE-II.	TRIPS might be a useful triage and/or evaluation tool for transport services.
Mathur 2005 / India	Prospective cohort of referred neonates with hypothermia	Transport from the community (homes and health facilities) to a referral neonatal unit of a teaching hospital	100 referred neonates with hypothermia (temperature <36.5°C)	NR	Mortality rates in neonates with mild, moderate, and severe hypothermia	Mortality was 39.3% in mildly hypothermic neonates, 51.6% in moderately hypothermic, and 80% in severely hypothermic. Mortality was increased significantly for all groups in the presence of associated illness, physiologic derangements, and weight <2.0kg. 36% of neonates were transported naked, only 5% had their head covered with a cap, and all were transported in open vehicles (cycle-rickshaw, auto-rickshaw, public bus, and scooter).	WHO classification of severity of hypothermia correlates with the risk of fatality but should also include the presence of associated illness (birth asphyxia, neonatal sepsis, and respiratory distress), physiological derangements (hypoxia, hypoglycemia, and shock), and weight <2.0kg as adverse factors that should classify hypothermia in the next higher category of severity.

Mathur 2007 / India	Prospective cohort of referred neonates over 10 months	Transport from the community (homes and health facilities) to a neonatal nursery of a teaching hospital	175 referred neonates with weight >1.0kg	3/2003-12/2003	TOPS (Temperature, Oxygenation, Perfusion, and blood Sugar) and SNAP-II as predictors of mortality	All the TOPS variables had significant correlation with fatality on univariate analysis. The total correct classification rate for TOPS was 81.7%, while that for SNAP-II was 83.4%.	TOPS has an equally good prediction for mortality as SNAP-II and can be used as a simple and useful method of assessment of risk of fatality immediately upon admission of a referred neonate.
Sehgal 2001 /India	Prospective cohort of referred neonates over 4 months	Transport from homes, primary health centers, public and private hospitals to an emergency unit of a children's hospital	95 referred neonates (35 deceased, 60 survived)	8/1999-11/1999	Deceased and surviving neonates	36% of patients died (70% within 6 hours of arrival). Factors significantly contributing to mortality included: lower birth weight, prematurity, hypothermia, hypoglycemia, poor perfusion, and longer transport time. Only 5% of patients were transferred by ambulance (the others were brought by various vehicles such as cars, jeeps, auto-rickshaw, and bicycle-rickshaws). No referrals were accompanied by trained health personnel. No patients were fed during transport.	Feeding during transport is important to help regulate hypoglycemia, a contributing factor to mortality. Low-cost transportable devices that help with the application of heat (transparent insulating bags, Saran wrap, plastic heat shield) will help reduce mortality. Communication with referral centers is critical so that they are able to prepare for the needs of the arriving neonate.
Silveira 2003 / Brazil	Prospective cohort of referred neonates over 3 months	Transport from homes or health centers to the Instituto Materno Infantil de Pernambuco	320 referred neonates (61 with moderate hypothermia, 259 controls with mild or no hypothermia)	3/2000-6/2000	Mortality in neonates with moderate and mild/no hypothermia	Risk of death was higher (RR = 3.09) in the neonates exposed to moderate hypothermia (temperature between 32.5°C-35.99°C) than in the non-exposed group (temperature >36°C).	Hypothermia on admission is an independent risk factor for neonatal death and thermal control should be an important part of neonatal transport.

Author/Country	Study Design	Levels of Care	Participants	Dates of Study	Comparison	Results	Recommendations
Singh 1996 / India	Prospective cohort of referred neonates	Transport from "various places" to a tertiary level hospital	110 referred neonates (73 with normal temperature, 16 hypothermia, 21 hyperthermia)	NR	Neonates with normal temperature, hypothermia, and hyperthermia	Mortality was significantly higher in hypothermic (56.2%) and hyperthermic (52.4%) neonates compared to euthermic (12.3%) neonates. Transport vehicles included car (73.6%), open jeep (6.4%), bus (5.4%), ambulance (3.6%) and rickshaw (10.8%). No transport involved medical personnel or monitoring. Methods for thermal control were inadequate in all cases.	Methods to regulate temperature instabilities of neonates during transport need to be improved and open vehicles should not be used because temperature maintenance in these vehicles is not possible.
Vieira 2011a / Brazil	Cross-sectional study (nested in a prospective cohort) of referred neonates over 12 years	Intra-hospital transport of NICU patients (i.e. for surgical and imaging procedures)	640 transported neonates submitted to 1191 intra-hospital transports (182 with hypothermia, 1009 without)	1/1997-12/2008	Neonates with and without hypothermia (<36.0°C)	Hypothermia occurred in 15.3% of transports and was associated with weight at transport <1.0kg (OR 3.7), weight at transport 1.0-2.5kg (OR 1.5), pre-transport axillary temperature <36.5°C (OR 2.0), central nervous system malformation (OR 2.8), use of supplemental oxygen (OR 1.6), mechanical ventilation prior to transport (OR 2.5), and transport for surgeries OR 1.7).	Intra-hospital transports present an increased risk for hypothermia and should be conducted by skilled transport teams with adequate equipment.
Vieira 2011b / Brazil	Prospective cohort of referred neonates over 12 years	Intra-hospital transport of NICU patients (i.e. for surgical and imaging procedures)	641 transported neonates submitted to 1197 intra-hospital transports (327 with clinical complications, 870 without)	1/1997-12/2008	Neonates with and without clinical complications	Clinical complications occurred in 27.3% of transports and were associated with CNS malformations (OR 1.6), surgery (OR 4.0), pre-transport supplemental oxygen (OR 4.0), pre-transport assisted ventilation (OR 5.0), and duration > 120 minutes (OR 1.6).	Intra-hospital transports are associated with increased risk of clinical complications and should be conducted by skilled transport teams with adequate equipment.

Vieira 2011c / Brazil	Cross-sectional study (nested in a prospective cohort) of referred neonates over 8 years	Intra-hospital transport of NICU patients (i.e. for surgical and imaging procedures)	695 transported neonates (301 during even years, 394 during odd years)	1/2001-12/2008	Neonates admitted during even years (used as a derivation cohort to determine relevant variables for a predictive score) and odd years (used as a validation cohort)	Variables included in the final multiple logistic regression model for clinical complications during intra-hospital transports included gestational age, pre-transport body temperature, underlying disease, transport destination, and type of respiratory support. At least one clinical complication occurred during 22.9% of transports (hypothermia in 12.7%, hyperoxia in 5.6%, desaturation in 4.1%, and the need for increased respiratory support in 2.3%).	Predictive scores can be developed and validated to identify infants at risk of clinical complications during intra-hospital transports.
Adherence to norms and guidelines							
Albuquerque 2012 / Brazil	Prospective cohort of referred neonates over 6 months	Transport from secondary health units to a NICU	75 referred neonates	7/2004-12/2004	High, average, and low conformity to existing norms (based on an arithmetic mean calculated for each neonatal transport)	24% of transports had high conformity, 46.7% average conformity, and 29.3% low conformity. ~70% of newborns were transported in an inadequate manner, and no newborn was transported in full accordance with the existing norms.	Neonatal transport systems need improvement in following existing norms, especially with regards to pre-transportation communication, the adequacy of the team and transport unit, and clinical conditions on arrival.
Butt 2007 / Pakistan	Case-control study of referred neonates with HIE and matched controls over 4 months	Transport from homes, primary health centers, public hospitals, and private health facilities to a NICU in the Children's Hospital Lahore	340 referred neonates (153 cases with HIE, 187 controls without HIE)	3/2005-6/2005	Neonates with HIE and matched controls without HIE admitted on the same day	Only 11.1% of neonates carried a referral letter; those with v. without HIE were not significantly more likely to carry a referral (14.4% v. 8.6%). Neonates seen by a physician were statistically more likely to carry a referral letter than those seen by other health care providers (17.3% v. 2.8%).	Maintaining good standards in medical note keeping and referral documentation is an important aspect in planning further patient management and counseling parents about their infant's prognosis. Such practices should be regularly audited.

Author/Country	Study Design	Levels of Care	Participants	Dates of Study	Comparison	Results	Recommendations
Hadley 2001 / South Africa	Retrospective cohort of referred surgical neonates over 9 months	Inter-facility transport from several hospitals and some intra-facility transport from the obstetric ward to a surgical nursery at a tertiary hospital	126 referred surgical neonates (21 intra-facility transports)	1/1999-9/1999	Compliance and non-compliance with a standard of care	Of those patients with a nasogastric tube in place upon arrival, 19% were non-functioning (due to spigotting or knotting). Of those patients arriving with an intravenous cannula, 28% had the drip turned off and 28% had non-functioning infusions. Only 64% of patients had radiographs with them upon arrival (resulting in 36% having to repeat imaging).	Educational interventions are likely to have a greater impact than further technological advances. Maintaining simple interventions during transport, such as intravenous fluid replacement, nasogastric drainage, and the administration of oxygen, should be made priorities in the management of surgical neonates. Transport personnel should be trained specifically for neonatal transfer.
Mutlu 2011 / Turkey	Prospective cohort of referred neonates over 12 months	Inter-facility and intra-facility (emergency department) transport to a NICU	216 referred neonates	1/2007-12/2007	Infants with referrals that were informed previously and not informed previously Conformity with regional norms Premature and term neonates	The most common errors before and during referral were absence of IV line and/or inappropriate type or amount of IV fluid (61%) or errors related to respiratory support (20%) (obstruction or dislocation of intubation tube or inadequate oxygen supply). No transport vehicle was observed to have a mechanical ventilator, monitor, or neonatal pulse oximeter. Only 58% of accompanying medical personnel had received neonatal resuscitation training. 71% of neonates carried a referral note.	Transport equipment should be continuously checked to make sure it is functioning properly. Transport vehicles should be prepared for the requirements of a sick neonate. Experience and training of accompanying health care workers should be appropriate to care for a sick neonate. Accurate and timely communication between referring providers and a neonatologist at the referral facility should help eliminate unnecessary referrals. Detailed referral notes should accompany patients.
Nakhshab 2010 / Iran	Cohort of referred neonates over 6 months	Inter-facility transport from various regional hospitals to a NICU	148 referred neonates	6 months (NR)	Conformity with regional norms	Only 50% of patients had an arterial blood gas, chest x-ray, and blood sugar checked before transport. 10.1% were hypothermic upon arrival to NICU	The current neonatal transport system needs to be improved (including regionalization, communication, optimal equipment, and skilled personnel).

Roux 1989 / South Africa	Case-series of referred neonates over 2 months	Inter-hospital transports	15 referred neonates (11 by private ambulance, 4 by provincial ambulance)	5/1987-6/1987	Conformity with transport norms	Quality of inter-hospital transports, especially by private ambulance, was not up to standard and included deterioration of body temperature, heart and respiratory rates, and serum glucose values.	Lack of equipment in ambulances increases the risk of neonatal transport. Staff development and a national control body are recommended.
Team training and composition							
Chandy 2007 / Cambodia	Prospective cohort of trained care providers over 2 years	Training of care providers from a rural region (villages, several health centers, 3 referral hospitals)	305 providers (160 TBAs, 96 village trauma first helpers, 30 midwives, 19 doctors/medical assistants)	2004-2006	Self-rated skills, confidence, and quality of team work before and after completing a delivery life support training course	Significant improvement occurred in overall knowledge, confidence, hands-on skills, and quality of team work as assessed by a user-skill survey at the completion of the training course.	The Delivery Life Support program trains rural care providers (TBAs, midwives, paramedics, medical assistants, and physicians) to regard delivery as a potential trauma requiring stabilization and possible transport.
Kumar PP 2011 / India	Prospective cohort of referred neonates over 13 months	Transport from pediatric, maternity centers to a tertiary pediatric hospital	151 referred neonates	3/2008-3/2009	Physiologic characteristics of neonates pre- and post-stabilization by a specialized neonatal transport team	Significant improvement in rates of hypoglycemia, hypothermia, hypoxia, and hypotension occurred after being stabilized and transported by a specialist transport team.	Proper training and adequate pre-transport stabilization by a specialist transport team can decrease transport-related morbidity.
Kumar PP 2010 / India	Retrospective cohort of referred neonates by land transport over 4 years	Transport from various maternity and pediatric centers to a tertiary pediatric hospital	1015 referred neonates (795 within-city transports, 220 out-of-city transports)	7/2004-6/2008	Biochemical and physiologic characteristics of neonates transported short (within city limits) and long distances (outside city limits)	Biochemical and physiologic characteristics (arterial pH,O_2 saturation, core temperature) and 24- hour mortality rates were not significantly different between neonates transferred for short versus longer distances.	Long-distance road transfer of neonates by a trained and qualified team can lead to results comparable to short-distance transport.

Author/Country	Study Design	Levels of Care	Participants	Dates of Study	Comparison	Results	Recommendations
Kumar PP 2008 / India	Retrospective cohort of referred neonates over 33 months	Transport from various maternity and pediatric centers to a tertiary pediatric hospital	288 referred neonates (160 with a specialized neonatal transport service, 128 on their own)	7/2004-3/2007	Neonates transported by a specialized neonatal transport service and neonates transported on their own	Incidence of hypo/hyperglycemia, hypo/hyperthermia, hypoxia, and apnea were significantly higher in neonates transported on their own compared to those transported by a specialized neonatal transport service. Significantly more neonates who were transported by a specialized transport service survived (96.2%) compared to those transported on their own (89%).	Specialized neonatal transport services could improve survival rates and decrease biochemical abnormalities of transported neonates.
Martínez Verónica 2011 / Mexico	Before and after (quasi-experimental) study of referred neonates over 4 years	Transport from the interior of the state of Jalisco and metropolitan Guadalajara to a NICU	3,277 neonates (384 pre-intervention, 2,893 post)	2005-2009	Program criteria pre- and post-S.T.A.B.L.E. (Sugar and Safe Care, Temperature, Airway, Blood, Lab work, Emotional support) training for medical and paramedical staff	More patients had normal body temperature (post 87% v. pre 59%), normal range of blood glucose values (93% v. 45%), incubator use (97% v. 52%), and pulse oximetry monitoring (89% v. 61%) in the post v. pre-intervention group. Decreased mortality (post 14% v. pre 22%) occurred during hospitalization in the post-intervention group.	The S.T.A.B.L.E. program training course for medical and paramedical transport personnel was highly effective, easy to implement, and resulted in a significant improvement in neonatal morbidity rates.
Spector 2009 / Panama	Before and after (quasi-experimental) study of referred neonates over two separate 7-month periods	Transport from 10 outlying birthing centers to a NICU	282 referred neonates (136 pre-intervention, 146 post)	11/2006-1/2008	Program criteria pre and post-S.T.A.B.L.E. (Sugar and Safe Care, Temperature, Airway, Blood, Lab work, Emotional support) training course for medical and paramedical staff	Significantly more neonates in the post-intervention group had temperatures within a normal range (post 56% v. pre 36%). No statistical difference was observed in serum glucose levels, length of stay, or mortality.	Implementation of a neonatal provider educational program (S.T.A.B.L.E.) can be used to improve thermal control of transported neonates.

Equipment							
Gosavi 1998 / India	Prospective cohort of high-risk referred neonates over 5 months	Inter-facility transport between 3 urban hospitals	32 high-risk neonates	10/1994-2/1995	Temperatures of neonates pre- and post-transfer using a commercially available styropor box as an incubator	No neonate became hypothermic or required resuscitation during transport.	It is possible to maintain normal temperatures of neonates during transportation by using a styropor box and bubbling oxygen into the box to maintain oxygenation.
Joshi 2010 / India	Prospective cohort of transferred neonates	Intra-facility transport between a neonatal care ward and operating room (~100 m)	~60 transferred neonates	NR	Temperature of neonates pre- and post-transfer using a neonatal carrier and warm wraps	No significant temperature differences were reported pre- and post-transport with neonatal carrier. Temperature difference was significantly less with a neonatal carrier (< 0.5°C) than with warm wraps (1.0°C).	A cheap and easily fabricated cardboard neonatal carrier (40 x 40 cm2) can be used to transport neonates short distances (~100m) with effective thermal control.
Khodadadeh 2001 / Iran	Prospective cohort of non-distressed premature neonates over 6 months	Neonates admitted to a neonatal care unit	45 non-distressed premature (<37 week GA) neonates weighing between 1.5-2.5kg (25 tested in a prototype non-electric incubator, 20 tested in a commercial electric incubator)	12/1999-5/2000	Vital signs of neonates using a prototype non-electric transport incubator and neonates using a commercial electric incubator.	No significant difference was observed in vital sign measurements taken for 2 hours (oxygen saturation, heart rate, respiratory rate, rectal temperature) between the two groups.	A non-electric transport incubator was shown to be safe and effective in providing thermal regulation for non-distressed premature babies over a 2-hour period and could be used to transport neonates to higher levels of care in developing countries.

Author/Country	Study Design	Levels of Care	Participants	Dates of Study	Comparison	Results	Recommendations
Access/Health system							
Araújo 2011 / Brazil	Prospective cohort of referred preterm neonates over 2 years	Transport of Sistema Único de Saúde patients from hospitals of the northeast region of Rio Grande do Sul and inborns from the maternity ward to a NICU	184 neonates (61 outborns, 123 inborns)	8/2008-7/2010	Transported neonates and neonates born in the maternity ward of the reference hospital (paired according to GA)	Transport group had a greater incidence of hyperglycemia (RR=3.2), hypoglycemia (RR=2.4), hyperthermia (RR=2.5), and hypoxemia (RR=2.2).	Perinatal care and transport should be better organized in the northeastern region of Brazil.
Dicko 2010 / Mali	Cross-sectional study of neonatal admissions over 3 months	Transport from the community to a neonatology unit at a teaching hospital (and inborns)	1072 neonatal admissions (760 outborns, 312 inborns)	10/2006-1/2007	Inborns and outborns	Factors related to neonatal mortality included maternal illiteracy, small weight at birth, and outborn birth.	Reduction of neonatal morbidity and mortality requires an improvement in the reference system.
Enweronu-Laryea 2008 / Ghana	Before and after (quasi-experimental) study of neonates admitted over 2 years	Transport from homes, primary health facilities, public hospitals, and private hospitals to a NICU and inborns	465 outborn neonates (178 pre-upgrade, 287 post-upgrade)	10/2003-9/2005	Pre and post-upgrade in NICU facilities from level I to level IIIA (improved infant care area, handwashing facilities, radiant warmers, incubators, physiological monitoring, and lab equipment)	4-fold increase took place in outborn referrals for infants >2.5kg. Survival improved significantly for inborn neonates <2.5kg and outborns <1.5kg.	Investments in NICU facilities should be accompanied by improvements in emergency obstetric services, human resources, neonatal resuscitation practices, and referral/transport systems. [This article was included as an intervention affecting Phase III delays. Increased outborn referrals occurred after improvements in NICU facilities.]

Kumar M 2002 / India	Retrospective cohort of neonates admitted over 6 years	Admissions to a subdistrict hospital (first level referral facility for essential newborn care services) from the community and the obstetric ward	7137 neonates (6746 inborns, 385 outborns)	1994-1999	Inborns and outborns	56 deaths (0.8%) occurred among inborn group and 70 deaths (18.2%) in outborn group. Main causes of death in the inborn group were birth asphyxia (37.5%) and prematurity (46.4%) and main cause of death in the outborn group was sepsis (71.4%).	Prevention of deaths due to birth asphyxia and prematurity (primarily occurring in the first week of life) should include the promotion of institutional deliveries or care by a skilled attendant at birth while prevention of deaths due to sepsis (primarily after the first week of life) should include training health care workers in early detection of sepsis and sepsis management. An effective referral system from the community and to secondary/ tertiary specialty care is a necessity.
Lu 1999 / Taiwan (China)	Before and after (quasi-experimental) study of referred neonates during two separate time periods	Transport from Level I units (obstetric clinics providing care for normal neonates) to Level II (district or regional hospitals) and Level III (NICU) units	733 referred neonates (260 before implemen-tation of National Health Insurance, 473 after implemen-tation)	7/1991-5/1992 8/1997-3/1999	Pre- and post-implementation of National Health Insurance	The incidence of hypoglycemia (pre 26.8% v. post 13%), acidemia (35.3% v. 26%), infant mortality (19.7% v. 9.3%), and discharge against medical advice (4.2% v. 0.4%) decreased in the second period after implementation of National Health Insurance.	Improved outcomes of transported neonates are related to the establishment of a network of perinatal services, including educating providers to identify high-risk neonates and perform neonatal resuscitation, training transport teams, and improving consultation and communication.
Ndiaye 2003 / Senegal	Retrospective cohort of low birth weight neonates referred over one year	Transport from public or private health facilities in Dakar and surrounding areas to a neonatology service at a regional hospital	686 low birth weight (<2.5kg) neonates 506 low birth weight inborns (112 deceased) 180 low birth weight outborns (117 deceased)	1/1998-12/1999	Inborn and outborn low birth weight neonates Deceased and surviving low birth weight outborn neonates	Outborn mortality ratio was 65% and inborn 34.5%. Delay of admission, methods of transport, maternal age, parity, and Apgar scores did not differ significantly between deceased and surviving outborns. Ambulance transport was used in only 10% of cases.	Improvement in the capacity for resuscitation and stabilization in community hospitals and creation of a more organized neonatal transport system to the regional hospital are needed.

Author/Country	Study Design	Levels of Care	Participants	Dates of Study	Comparison	Results	Recommendations
Upadhyay 2013/ India	Cross-sectional study of deceased neonates during a 1 year period by verbal autopsy and social audit	Home visits in 28 rural villages	50 deceased neonates (22 due to Phase I delays, 17 Phase II, 14 Phase III, and 13 with no delay—5 deaths had all 3 delays and 13 deaths had 2 delays)	2010 deaths	Mortality in Phase I, Phase II, and Phase III delays (as defined by Thaddeus & Maine, 1994)	44% overall mortality was due to Phase I, 34% due to Phase II, and 28% due to Phase III delays (some deaths were not due to any delays and some due to multiple delays). 41.2% of Phase II delays were due to absence of an accompanying family member, 23.5% to unavailability of transport, 23.5% to long distance to health facility, and 11.8% to lack of funds.	Delays in deciding to seek care and transport-related delays are major contributors to newborn deaths and efforts to improve newborn survival need to address both concurrently.
Uslu 2011 / Turkey	Before and after (quasi-experimental) study of referred neonates over 1 year	Transport from external centers in 15 different provinces to a NICU	2452 referred neonates (1525 pre-intervention, 927 post-intervention)	3/2007-8/2007 1/2008-4/2008	Pre- and post-neonatal transport improvements (including educational sessions for healthcare personnel, purchases of ambulances and transport equipment, neonatal resuscitation programs, compulsory use of a “Neonatal Transport Form”, and official reporting of referrals)	Incidence of hypothermia, hypoglycemia, and hypotension were decreased after transport improvements were implemented. TRIPS score (pre 20.07 v. post 11.53) and mortality rate (18.4% v. 14.1%) were significantly higher in infants in the pre-intervention group. Higher incidence of pre-transport communication, presence of a detailed discharge and birth reports, ambulance and incubator use, proper use of intravenous fluids, and intubation characterized the post-intervention group.	Improvements in neonatal transport conditions (educational programs for providers, improved vehicles and equipment, and official and compulsory documentation and reporting) can lead to decreased neonatal morbidity and mortality.

Waiswa 2010 / Uganda	Retrospective cohort study of deceased neonates by verbal and social autopsy over 4 years	16 rural health facilities (52 health providers)	64 deceased neonates	1/2005-12/2008	Mortality in Phase I, Phase II, and Phase III delays (as defined by Thaddeus & Maine, 1994)	50% of overall mortality was due to Phase I delays, 20% due to Phase II delays, and 30% due to Phase III delays.	Efforts to improve newborn survival need to address concurrently household and health facility-related delays in seeking appropriate care.
Wang 1997 / Taiwan (China)	Prospective cohort of referred neonates over 1 year	Transport from 51 obstetric clinics (level I) to 8 district hospitals (level II) and 1 tertiary center	254 referred neonates (180 to level II units, 74 to level III units)	7/1991-6/1992	Infants transferred to level II and level III units	Overall mortality rates were 1.5 times higher and mortality rates for ventilated neonates were 3 times higher in level II v. level III units.	Transport morbidity and mortality could be improved by better recognition in level I units of appropriate level of referral, improved capability of level II units to treat sick neonates, and increased bed capacity in level III units.
Woodward 1997 / Hungary	Before and after (quasi-experimental) study of live births over 6 years	Inter-facility transport from various hospitals, imaging facilities, or surgical centers to 5 NICUs and one cardiac care unit	716,853 live births (298,504 in area with dedicated transport team, 418,349 in control area without dedicated transport team)	1990-1995	Early neonatal mortality rate (0-6 days) in areas with and without a dedicated transport team	Mortality rates were significantly lower in an area with a dedicated neonatal transport team (6.9 per 1000 live births) compared to a control area without a transport team (7.7 per 1000 live births).	A structured and specialized neonatal transport service can lead to decreased neonatal mortality.

CFT = capillary filling time; CLD = chronic lung disease; GA = gestational age; HIE = hypoxic ischemic encephalopathy; IV = intravenous; NICU = neonatal intensive care unit; NR = not reported; RR = risk ratio; SNAP-II = Score for Neonatal Acute Physiology II; SNAPPE-II = Score for Neonatal Acute Physiology Perinatal Extension-II; TBA = traditional birth attendant; TOPS = Temperature, Oxygenation, Perfusion, and blood Sugar; TRIPS = Transport Risk Index of Physiologic Stability; TTN = transient tachypnea of the newborn; VLBW = very low birth weight.

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Discussion

Summary of evidence and recommendations

The evidence included in this systematic review substantiates the need for establishment of neonatal transport services to provide equitable and widespread access to high-quality care for infants in the first month of life. Infants born in the community or in first-level facilities who require transport to higher levels of care continue to experience disproportionately high mortality and morbidity compared to infants born in a center capable of delivering needed care. However, improvement in the quality and organization of transport systems alone is insufficient. Implementation or improvement of a transport system must be accompanied by a system for regionalization of care within a referral network and strengthening of the capacity to deliver high-quality care to meet the demand at every level of the perinatal health system. Unanticipated consequences, such as increased referral of neonates who should be able to receive adequate care in their facility of birth, can limit the overall impact of transport and health system improvements. Similarly, referral of acutely ill neonates to a facility inadequately prepared (either with personnel or equipment) to care for them also results in suboptimal outcomes. Structural changes in the health system, such as implementation of universal health coverage for pregnant women and newborns, can result in improvements in quality of perinatal care, transport, and access to services.

Improvements in outcomes of neonatal transport can be achieved readily by focusing on the critical, yet basic, issues of physiological stability. In order to accomplish improved quality of care during transport, there is a need for proper equipment and vehicles, training and availability of personnel, and norms for organization, administration, communication, and clinical care. Oversight of national-level authorities or professional bodies may be necessary to achieve adherence to established regulations and guidelines.

Specific training in patient assessment and management of common problems of transported neonates is likely more important than the particular professional composition of the team. Scores for severity of illness and specifically developed scales for monitoring physiologic stability in transport can improve quality of care and may be useful in triage of patients to appropriate referral centers. The impact of educational programs may not be uniform, however, because education must be accompanied by necessary systems change and must result in sustainable change in behavior.

Limitations and gaps in research

The evidence available for review reflects a lack of well-controlled, active intervention trials to improve the quality of care during transport, the vehicles and equipment used during transport, and the administration and management of transport services. There were no studies designed to provide the highest level of evidence (randomized controlled trials, cluster-randomized trials, or controlled clinical trials). Few studies carefully examined packages of interventions, combining, for example, team training with improved equipment and vehicles and more rigorous transport guidelines. No studies reported on systematic assessment of need for transport integrated with comprehensive health system planning.

There were notable gaps in certain areas of the evidence identified for the systematic review. Although hypothermia was identified in multiple studies as a major morbidity encountered during neonatal transport, there were few studies identified that evaluated equipment or modalities such as skin-to-skin care to provide thermal support during transport. There were no studies identified from developing countries that compared different modes of medical transport (ground, water, air ambulance (fixed wing, helicopter), bicycle ambulance, backpack/carrier). Evaluations of equipment and operational functions may reflect publication bias or publication of such studies in journals not included in the databases searched.

Identification of related articles by authors of included studies was hampered by inconsistent application of conventions for indexing author names. Disproportionate difficulty accessing literature from certain regions of the world may result from several factors. These include variability in the order of surnames and given names (especially in studies from China), confusion created by inconsistent use of paternal and maternal surnames (as in Spanish and Portuguese), and uncertainties in alphabetization and indexing for authors whose surnames include “da” or “de.”

Conclusions

The studies included in this review highlight the scarcity of high-level evidence relating to neonatal transport in developing countries. The findings from non-randomized studies without control groups should be interpreted with caution and do not provide an independently sufficient evidence base for formulation of guidelines. However, the available studies do reveal the prevalence of inadequate systems for neonatal transport in low- and middle-income countries of all regions of the world. Difficulty in maintaining thermal stability is the fundamental challenge that most directly impacts neonatal morbidity and mortality. The capacity to provide additional condition-specific care for respiratory distress and prematurity, surgical conditions, and sepsis and its complications also directly influences neonatal morbidity and mortality. Even where norms or guidelines exist, adherence to such standards of performance is low. Training of

personnel to adequately and continuously assess the physiologic stability of neonatal patients and correctly employ basic equipment and techniques to stabilize patients before and during transport can improve outcome. Diffusion of innovation in equipment designed for neonatal transport in resource-limited settings is limited. Planning for development of neonatal transport systems must be integrated not only with similar efforts directed toward pregnant/postpartum women and pediatric patients, but also with development of a coordinated system of perinatal and maternal-child care. To realize the potential life-saving value of neonatal transport, three steps are essential: (1) strengthening capacity for prevention/recognition/stabilization at the community and first-level health facilities; (2) designing systems for ready access and effective triage and transport of patients to higher levels of care; and (3) increasing capacity in terms of skills and volume at the higher levels of care.

Future directions

Areas for future research

As efforts to improve neonatal survival expand, the demand for access to safe and effective neonatal transport will only increase. Educational programs for neonatal resuscitation, essential newborn care, and prematurity prevention/care all currently incorporate messages around formulation of an emergency plan, including transportation and communication to a health facility. This situation presents an opportunity to design controlled intervention trials for effectiveness in reducing morbidity and mortality associated with neonatal transport. Ideally, trials will incorporate packages of interventions shown to have impact on infant outcomes, including such elements as:

- Pre-referral stabilization at site of origin of transport
  - surfactant administration
- Referral documentation
- Communication between referring site and receiving (referral) facility
  - to initiate transport
  - to direct transport to appropriate receiving facility
  - during transport (advice for patient management)
  - post referral follow-up to referring site
- Transport vehicles and equipment
  - Requirements for minimum equipment and for specific equipment for each medical facility, e.g., incubator, infusion pump, feeding tube, nasogastric suction, cardiorespiratory monitoring, oximeter, non-invasive blood pressure monitoring, temperature monitoring and feedback control, blood glucose monitoring, intravenous fluids, antibiotics, anticonvulsants

    - vehicle selection, operating characteristics, critical maintenance
- Team composition and training
    - staffing
    - professional role (physician, nurse, respiratory therapist, emergency medical technician)
    - training in resuscitation and stabilization, assessment
- Kangaroo care and other alternative methods for maintaining thermal stability (aluminum foil, silver swaddler, chemical warming mattresses, low-cost incubators)
- Triage and evaluation tools
- Quality improvement efforts focused on transport
    - critical incident analyses
    - case reviews
    - monitoring
- Cost-benefit analysis (DALYs, life-expectancy)
    - sources of financing for transport
- Family satisfaction

Specific strategies to promote rigorous research directed toward development of low-cost, technologically appropriate equipment for neonatal transport might take advantage of the fact that technology is currently a strong global funding priority. Grant programs such as the Gates Foundation Grand Challenges series support such development, as do multiple university partnerships among medical, nursing, and bioengineering faculty. The mechanism of the Global Development Alliance, such as the public-private partnerships organized by the United States Agency for International Development, also offers opportunities to collaborate with industry in the development of appropriate technology and purpose-built devices.

Development of guidelines

Development of guidelines for neonatal transport has generally occurred by incorporation of specific practices and principles from the various fields that contributed to its genesis: neonatology, pediatric critical care and emergency medicine, pediatric surgery, trauma, and emergency medical services for children. Guidelines must meet the needs of policymakers, hospital and health system administrators, communications personnel, and the clinicians directly involved in patient care. Previous guidelines have relied heavily on expert opinion and consensus. However, the available evidence can be incorporated to support recommendations, especially for developing countries seeking to improve or establish neonatal transport systems.

Neonatal transport must be situated in the larger context of regionalized perinatal care, encompassing care of the pregnant woman and the fetus as well as the newly delivered mother and her infant. Timely referral of the pregnant woman and in utero transport of the undelivered fetus has been shown to improve outcome for a variety of neonatal medical conditions in the developed world, including extreme prematurity and complex congenital malformations. Timely referral for cesarean section can prevent morbidity and mortality from intrapartum-related events (asphyxia). After delivery, transport of mother and infant together is critical to support exclusive breast-feeding and employ skin-to-skin care as a means of thermal control during transport. However, admission of both the mother and baby to the referral facility requires changes in policy, financing, and capacity.

The evolution of a neonatal transport system naturally moves from an initial focus on the most common reasons for referral (including moderate prematurity, hypoxic-ischemic encephalopathy, sepsis, and surgical conditions) to increasingly sophisticated interventions for complex, high-acuity conditions (such as extreme prematurity with respiratory distress, pulmonary hyper tension, and critical congenital heart disease). This progression in sophistication ideally parallels that occurring in the health system as a whole. Rational use of transport calls for basic care for infants 1800–2500 grams and above to occur in first-level centers close to the community. Referrals to level II centers are indicated for moderate illness, and tertiary centers are reserved for management of the highest-risk infants, as predicted by illness severity scores or need for mechanical ventilation or surgical intervention. As the severity of illness increases, the need for a centralized transport system also increases in order to assure full availability of appropriate trained personnel, equipment, and protocols. With increasing complexity of disease come difficult decisions on investment of resources in intensive care rather than primary prevention and care.

Resources for development of guidelines

Existing guidelines for neonatal transport in the developed and developing world can serve as useful models for development of regional guidelines. The Section on Transport Medicine of the American Academy of Pediatrics (AAP) updated *Guidelines for Air and Ground Transport of Neonatal and Pediatric Patients* in 2007 and also recently issued the results from a national consensus conference on pediatric and neonatal interfacility transport (Stroud 2013). The Asociación Española de Pediatría also recently issued updated recommendations on neonatal transport (Moreno Hernando 2013). Guidelines from the Brazilian Ministry of Health (Brasil, Ministério de Saúde 2010) and Argentinian Ministry of Health (Argentina, Ministerio de Salud 2012) also provide recent templates for implementation.

Additional resources to support the development of transport infrastructure globally include the *Handbook of Pediatric and Neonatal Transport Medicine* (Jaimovich and Vidyasagar 2002) and white papers on transport from the World Bank (Babinard and Roberts 2006) and the International Forum for Rural Transport Development (Lema 2009).

Framework for practical implementation of a neonatal transport system

Organization of a neonatal interfacility transport service

Prior to the organization of a neonatal transport system, planning and coordination at the national and regional level are necessary to align the goals and objectives of transport with those of the larger health system. Such a planning process includes:

- Alignment of targets for outcome improvement in health system and priority conditions (and exclusions) for transport
- Estimation of demand for care, by target condition and by region (met and unmet need)
- Development of primary and referral centers to meet demand for care (appropriate population-based distribution)
- Estimation of demand for transport to achieve equitable access to care (accounting for population distribution)
- Establishment of referral networks by target condition and by region (based on available subspecialties)

- Determination of administrative and governance model for transport system (governmental or private, independent organization or affiliate of hospital system)
- Definition of financial operating plan and revenue flows (alignment with covered benefits of health insurance plans, financial responsibility of sending and receiving hospitals [e.g. personnel], provision for uninsured patients or those with conditions outside covered benefits)

Transport program structure and administration

Transport may originate in the community, with local emergency services and a community health care provider accompanying the patient; however, transport vehicles in the community seldom have adequate equipment for care of neonates. Origination of the transport from the referral center enables more efficient use of appropriately equipped vehicles and offers the additional advantage that primary care providers remain in their assigned role and available to other persons needing services in the community. Delivering medical care in the context of transport requires a specific skill set; hence it is undesirable to use staff nurses (even very experienced intensive care nurses), residents, or fellows who do not have specific training in transport medicine.

The volume of transported neonates may not be sufficient to support a single-purpose transport team and system. Configuring teams to come together on an as-needed basis introduces delay; however, maintaining a 24/7 team exclusively for neonatal transports is usually cost-prohibitive. Many teams are structured to transport both neonatal and pediatric patients. Coverage between adult and neonatal/pediatric transport is difficult because of the very disparate diagnoses and skill sets, but it may be feasible to share transport vehicles. Sharing of communications and administrative infrastructure with adult transport is virtually mandatory.

Transport team members: mobile and in-facility clinicians and administrative support

Personnel are the most valuable element in a transport system. Trained personnel with the ability to provide appropriate care during transport are crucial to reducing mortality associated with long transport distances and optimizing outcome. Typical roles within a neonatal transport system include:

Medical director – pediatric/neonatal specialist with training in critical care and transport medicine, responsible for developing and reviewing policies and protocols, selecting and training personnel, approving equipment and therapeutic strategies, providing case review and oversight as well as outreach education, and managing quality improvement programs.

Transport coordinator (administrative director) – a health professional who is responsible for the daily activities of the transport team, including scheduling, selection and maintenance of equipment, data collection, budget management, training and compliance.

Coordinating (control) physician – pediatric/neonatal specialist with training in critical care who obtains information about the patient, offers advice on patient management before arrival of the team, provides supervisory contact during transport, and documents clinical data for use by the receiving facility. The coordinating transport physician also assures availability of bed space, appropriate team composition, and notification of other needed sub-specialists.

Transport team members - physicians, nurses, paramedic/emergency medical technicians, respiratory therapists, and pilots/drivers. Dedicated, specially trained nurses or advanced practice nurses may offer advantages over physicians in terms of cost, flexibility between inpatient/transport duties, familiarity with equipment, and specific training in monitoring/supportive functions. Physicians can participate effectively through regular communication with the on-site team throughout the transport as well as immediate availability for consultation in case of emergency. Emergency medical technicians are vital to the logistics of patient transfer (equipment functionality, vehicle loading and securement systems) and may also serve as drivers. When patients with respiratory conditions are transported under mobile NICU conditions, respiratory therapists can assume responsibility for air way and ventilator management, in conjunction with nurse specialists and supervising physicians.

Transport program personnel management, training, and assessment

The transport environment implies a degree of autonomy for clinicians and so the most valuable transport team members have considerable expertise. However, traits that support a high level of performance under demanding conditions are equally important, such as leadership, flexibility, independence, excellent communication skills, and ability to solve problems. The composition and training of the clinicians on the transport team should be matched to the mission and clinical scope of the team. A diagnosis-based educational checklist (based on the target conditions for transport) along with a curriculum in transport medicine/physiology can serve as a guide for development and maintenance of cognitive knowledge. There is usually a need for additional training to develop procedural skills to the level required for efficient, safe, successful performance under field conditions. Maintenance of skills and renewal of the knowledge base is critical, as is training of new staff members when turnover occurs. Transport team members should be directly involved in ongoing quality monitoring and quality improvement initiatives.

Communications and dispatch center/integration with EMS

Effective communication is required to coordinate the multiple parties involved in interfacility transport. A communication system should provide a standardized mechanism and routine for:

- Access to services by the referring provider
- Notification, briefing, and mobilization of the transport team
- Response to the referring facility
- Contact among the transport team, medical control physician, referring and receiving health providers, and communication center
- Follow-up to the referring facility/provider

Emergency transport medical communications systems may follow a number of models, including: (1) public safety and emergency dispatch centers (e.g., 911 system); (2) hospital-based communications centers (usually affiliated with and emergency department); (3) freestanding communications centers serving one or more transport programs; and (4) unit-based communications site (such as a NICU).

A communication center must operate 24 hours a day, 7 days a week with trained communications specialists. These specialists obtain patient information and assess the logistical aspects of transport to select the appropriate mode and coordinate each step according to policies and procedures. Phone systems and two-way radio systems (in the event of phone outages) form the

nucleus of the communications center; data links to emergency services, weather, and traffic/flight control centers characterize more sophisticated and larger systems.

Modes of transportation

Modes of transport vary from one region to another and depend upon patient acuity, geographical features, distance, transit time, weather patterns, and population density. Attention to the safety of the transport team and patient are the foremost considerations determining the mode of transport. All transport vehicles should provide oxygen and air in concentrations from 21% to 100%. Adequate lighting, climate control, and electrical power/outlets are especially important for assessment and care of neonatal patients. Expensive modes of transport, such as fixed-wing aircraft or helicopter, may be shared by several institutions. Vehicle operation (including fueling, maintenance, insurance, required licensure of drivers/pilots, etc.) may be core functions of the medical entity or of a contractor, or a hybrid approach.

Equipment and medications

Equipment and medications for neonatal transport differ to a great extent from the equipment and medications used in adult care. This requires a parallel but separate set of equipment and medications in services that care for both age groups. Equipment used in transport must meet several general characteristics:

- Appropriate for the age group and set of medical conditions to be addressed
- Lightweight, portable, rugged, easy to clean
- Secured in the transport vehicle for patient and team safety
- Tested in the transport environment (temperature, altitude, vibration)

Equipment to provide complete monitoring of heart rate, respiratory rate, temperature, blood pressure, and oxygen saturation is essential to achieving good patient outcomes. Thermoregulation and impact protection are especially important considerations for neonates, as is the ability to provide glucose-containing fluids (enterally or parenterally) and measure blood glucose. Portable suction is necessary for clearing the airway and gastric decompression. Ability to administer blended oxygen is standard. Ventilator care requires highly specialized equipment for operation under the conditions of transport.

Medications required in transport are dictated by the diseases encountered. In neonatal transport, certain medications such as prostaglandins and surfactant require refrigerated storage. Their use may be infrequent but the lifesaving nature of treatment justifies the expense of maintaining current stock where transport of infants with congenital heart disease or respiratory distress is part of the portfolio. Analgesics, sedatives, and other controlled substances require specific security and documentation; all medications must be routinely logged, restocked, inventoried, and replaced when outdated. Neonatal dosage references and dosage calculation aids are useful and improve safety of neonatal care.

Legal and compliance issues and safety

Transport involves the transfer of responsibility from the referring to the accepting providers and facility. The lines of responsibility and applicable laws, regulations, and administrative guidelines must be clearly defined. Legal issues can arise around violations of regulatory or licensure standards, as well as medical malpractice. Transport of non-patients (e.g. mothers and other family members of sick newborns) also raises issues of liability.

Quality improvement/data collection/accreditation

Continuous monitoring and evaluation of a transport program are vital to providing quality patient care. Transport must address the six characteristics of quality care: effective, timely, efficient, patient-centered, equitable, and safe. In addition to routine case review and review of patient care guidelines, quality improvement involves specific activities at every level of the transport enterprise, following the PDSA (Plan, Do, Study, Act) cycle or a similar program. Data collection is central to quality improvement, as is the feedback of results to the transport team/administrators. Accreditation is a voluntary process in which a board of experts evaluates a program or institution against measurable standards or criteria. Accreditation for medical transport is generally separate from accreditation of hospital services.

Transport physiology and stress

Providing care in a mobile environment involves understanding of the stresses placed on both patient and care providers. Noise, vibration, temperature swings, exposure to high humidity and/or dehydration can worsen patient condition and stress transport team members physically and emotionally. Air medical transport requires thorough understanding of physical gas laws, hypoxia, and flight physiology. Transport team members may face long, irregular duty hours under stressful circumstances. Stress management, debriefing and team health are important considerations to support continued quality of patient care.

Family-centered care

Family-centered care recognizes the important role of the family in the lives of children. For neonates, the role of the mother is central as a source of nourishment (breast milk) and warmth (skin-to-skin care). However, the acuity of a patient's condition and the need for rapid mobilization may lead to parental separation. Parents should be given the opportunity to accompany the transport when possible. At all times, parents should be given the opportunity to discuss their child's condition and management with transport team members.

Outreach education

An outreach education program should be incorporated into transport activities, with the goal of improving patient outcome. Outreach education can improve recognition of conditions requiring transport and stabilization before arrival of the transport team. Development of relationships between referring and receiving health care providers can also improve follow-up care and coordination of care.

Ethical considerations

Consent to administer medical treatment is generally obtained prior to transport. National law and cultural norms surrounding this process may vary significantly. However, minors generally do not have the legal authority to give consent, and thus a parent or legal guardian has this responsibility. In the case of an emergency that threatens life or health when a parent or guardian is not available, emergency services may be provided if the doctrine of implied consent is applicable.

Practical tools to support safe neonatal transport

There are a variety of resources that offer practical tools for education and job aids for safe neonatal transport in developing countries. Below are descriptions of several key texts, as well as a range of materials that pediatric professional organizations have developed for transport-team training and capacity-building of staff in neonatal care units.

Handbook of Pediatric and Neonatal Transport Medicine

The second edition of this book (Jaimovich and Vidyasagar 2002) includes extensive chapters on the medical conditions most commonly encountered in neonatal transport as well as sample forms and reference materials. The table of contents of the text is given below:

15. Transport Management of Acute Pediatric Asthma
16. Transport of Neonatal and Pediatric Patients Requiring Extracorporeal Life Support
17. High-Tech Respiratory Care on Transport

IV. Central Nervous System

18. Neonatal Neurological Problems
19. Transportation of the child with Seizures
20. Near-Drowning

V. Endocrine System and Metabolism

21. Endocrine and Metabolic Emergencies
22. Evaluation and Management of Renal Emergencies
23. Poisoning, Ingestion, and Overdose

VI. Trauma

24. Initial Stabilization and Transport of the Pediatric Trauma Patient
25. Central Nervous System Injuries
26. Cardiothoracic Injuries in Children
27. Abdominal Anomalies
28. Skeletal Injuries
29. Burns and inhalation Injuries

VII. Infectious Disease

30. Infectious Disease

VIII. Special Topics

31. Temperature Regulation and Management
32. Common Radiologic Findings in Pediatric and Neonatal Transport Patients
33. Transport Equipment and Techniques

Appendix I: Laboratory Values
Appendix II: Treatment Algorithms and Charts
Appendix III: Drug Therapy
Appendix IV. Pediatric Transport Protocols

Guidelines for Air and Ground Transport of Neonatal and Pediatric Patients

This extensive text, from the American Academy of Pediatrics (AAP), includes valuable practical tools for the operational aspects of a neonatal transport service. Other resources for initial stabilization prior to transport, management during transport, and emergency care are available through the AAP Division of Life Support.
www.aap.org

ACoRN, Acute Care of at-Risk Neonates

The ACoRN Neonatal Society, a Canadian society of volunteer professionals, publishes this book (ACoRN Editorial Board 2005), which provides health care professionals with a step-by-step framework to guide management of the sick newborn. The newest English-language update was published in 2012. There is also a Spanish-language eBook edition available from Amazon.com.
www.cps.ca/en/acorn

The National Neonatology Forum of India

This organization offers clinical practice guidelines for transport of a sick neonate and teaching aids for newborn care during neonatal transport.
http://bit.ly/29LREsi

Neonatal Resuscitation Program (NRP)

This AAP educational program in neonatal resuscitation for health professionals incorporates the guidelines and consensus on science of the International Liaison Committee on Resuscitation (ILCOR) as well as adult learning techniques utilizing simulation and skills practice to achieve competency.
http://www2.aap.org/nrp/

Helping Babies Breathe (HBB)

Based on the same science and guidelines as NRP, this educational program targets birth attendants in resource-limited settings and equips them with the skills to protect healthy babies and help those babies who do not breathe at birth through stimulation, clearing the airway, and bag and mask ventilation with air.
http://www.helpingbabiesbreathe.org/

Perinatal Continuing Education Program (PCEP)

A series of four workbooks provides educational tools for physicians, nurses, nurse midwives, respiratory therapists, and other providers of care for pregnant women and newborns. Content and activities are aimed at improving perinatal care policies, as well as practices and procedures,through establishing organization-wide care goals and routines.
Book I – Maternal and Fetal Evaluation and Immediate Newborn Care
Book II – Maternal and Fetal Care
Book III – Neonatal Care
Book IV – Specialized Newborn Care

S.T.A.B.L.E.

This neonatal education program focuses on the post-resuscitation/pre-transport stabilization care of sick infants. The title stands for the six assessment and care modules in the program: Sugar, Temperature, Airway, Blood pressure, Lab work, and Emotional support. A seventh module,

Quality Improvement, stresses the professional responsibility of improving and evaluating care provided to sick infants.

The S.T.A.B.L.E. instructional materials include a Learner/Provider Manual and and also an Instructor Manual. An accompanying slide program (Post-resuscitation/ Pre-transport Stabilization Care of Sick Infants, Guidelines for Neonatal Healthcare Providers) can be used for self-study or instructor-led presentations. These illustrations, photos, and animations are available on DVD or flash drive. A second slide set (Physical and Gestational Age Assessment of the Newborn) is available on CD-ROM or flash drive. An advanced module on care of the patient with congenital heart disease (Recognition and Stabilization of Neonates with Severe CHD) is available as a student handbook and slide program on CD-ROM.
www.stableprogram.org

PSSAT

Pre-transport Stabilization Self-Assessment (PSSAT) is a tool for quality improvement in S.T.A.B.L.E. The tool records data useful to assess the stabilization care provided to neonates requiring transport or transfer to another unit. Data are recorded from three time periods: Time A – at the time the transport is requested; Time B – upon arrival of the transport team in the referring nursery; and Time C – upon departure of the transport team. By using the recording of stabilization actions at each time period, nursing and medical review teams can assess the adequacy of pre-transport (or transfer) stabilization care.
http://www.stableprogram.org/stabilizationtool.php

Scores for severity of illness and transport physiologic stability

Scores for severity of illness and transport physiologic stability (SNAP-II, SNAPPE-II, TRIPS, TRIPS-II) are described in studies included in the systematic review and in the literature describing their development and refinement (Richardson 2001, Lee 2001, Lee 2013).

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Appendices

Appendix 1. PRISMA 2009 Checklist

Section/topic	#	Checklist item
TITLE		
Title	1	Identify the report as a systematic review, meta-analysis, or both.
ABSTRACT		
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.
INTRODUCTION		
Rationale	3	Describe the rationale for the review in the context of what is already known.
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).
METHODS		
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I2) for each meta-analysis.
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.

RESULTS		
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.
Synthesis of results	21	Present the main results of the review. If meta-analyses are done, include for each, confidence intervals and measures of consistency.
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).
DISCUSSION		
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.
FUNDING		
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.

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For more information, visit: *www.prisma-statement.org*.

Appendix 2: Search strategy

Neonatal Transport – keyword and MeSH – Ovid Search May 27, 2013

Concepts	Transport/access/referral	Neonatal conditions	Location
Key Words	(evacuation or stabilization or neonatal transport$ or neonatal retrieval$ or transport team$ or transport service$ or (bicycle or bicycles or bicycling or bike$) or (car or cars or ambulance$ or donkey$ or backpack$ or pouch$) or (phone$ or telephone$ or cellphone$)). ti,ab.	limited to birth to 1 mo	exp Developing countries/ or Medically underserved area/ or exp Africa/ or exp Central America/ or exp Latin America/ or exp South America/ or exp Asia/ or exp Carribean region/
MeSH	exp Transportation of patients/ or Transportation/ or Health services accessibility/ or exp "Referral and consultation"/ or Patient transfer/ or Telemedicine/ or Remote consultation/ or Bicycling/ or Motorcycles/ or Ambulances/ or Air ambulances/ or Aircraft/ or Taxi/ or Helicopters/ or Stretchers/ or Motor vehicles/ or Telecommunications/ or Satellite communications/ or Radio/ or exp telephone/ or Cellular phone/ or exp Emergency medical services/ or Health services, indigenous/ or Emergency treatment/ or Delivery of health care, integrated/ or Life support care/ or exp Emergency responders/ or Incubators, infant/ or Regional medical programs/ or regional health planning/	Hypothermia, induced/ or Hypothermia/ or Respiratory distress syndrome, newborn/ or Pneumonia/ or Hypoxia-ischemia, brain/ or Hypoxia, brain/ or Asphyxia neonatorum/ or Asphyxia/ or Sepsis/ or Hypotension/ or Hyaline membrane disease/ or Respiration, artificial/ or Fetal growth retardation/ or Hypoglycemia/ or Pneumothorax/ or Apnea/ or Airway obstruction/ or Respiratory insufficiency/ or Continuous positive airway pressure/ or Infant mortality/ or Body temperature regulation/ or Resuscitation/ or Infant, premature, diseases/ or exp Infant, newborn, diseases/ or Congenital anomalies/ or Intensive care, neonatal/ or Infant, premature/ or Infant, small for gestational age/ or Infant, low birth weight/ or Infant, very low birth weight/ or Infant, extremely low birth weight/	exp Developing countries/ or Medically underserved area/ or exp Africa/ or exp Central America/ or exp Latin America/ or exp South America/ or exp Asia/ or exp Carribean region/
Filters		Limited to birth to 1 mo	

Neonatal transport In developing country settings: a systematic review

Pan American Health Organization

World Health Organization
REGIONAL OFFICE FOR THE Americas

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