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REVIEW

Maternal Transport, What Do We Know: A Narrative Review

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Objective: This review examines the initial development of a transport system for neonates, followed by a subsequent evolution of a transportation system for the maternal/fetal unit, and then a maternal transport system (antepartum, intrapartum, and postpartum) to specifically address maternal morbidity/mortality.

Methods: A literature search was undertaken using the electronic databases PubMed, Embase, and CINAHL. The search terms used were "maternal transport" AND "perinatal care" OR "labor" "obstetrics" OR "delivery". The years searched were 1960–2023.

Results: There were 260 abstracts identified and 52 of those are the basis of this review. The utilization of a transportation system with the regionalization of levels of care has resulted in a significant reduction in neonatal, perinatal, and maternal morbidity and mortality. Although preterm delivery remains a concern in women transported, the number of deliveries that have occurred during transport is relatively small. Reimbursement for transportation continues to be a problem in several states.

Conclusion: A state-of-the-art transportation system has evolved that transfers neonates, maternal/fetal dyad, and pregnant women (antepartum, intrapartum, postpartum) to the appropriate level of care facility to ensure the best maternal/fetal/neonatal outcomes.

Keywords: maternal transport, maternal morbidity/mortality, perinatal morbidity/mortality, levels of care, pregnancy

Introduction

Specialized care for neonates and infants has evolved over the past 50 years with the development of neonatal intensive care units with physicians and nurses specialized in the management of the at-risk neonate in tertiary medical centers.[1] Maternal transport has become an integral part of this system by transporting mother with fetus in utero to these centers of specialized care, rather than delivery in smaller centers with subsequent transport of the neonate to the tertiary NICU. Significantly improved outcomes are the result when fetuses are transferred in utero rather than after birth.[2,3]

Maternal transport can be defined as a coordination of transporting the mother-fetal twosome to a location in which they can receive risk-appropriate care.[4] The fetal neonatal transport, system which transports the fetus in utero to a higher level of care, has more recently evolved into a specific maternal care system from a hospital where maternal care cannot be adequately provided because of the lack of specialist and sub-specialists to a hospital where antepartum, intrapartum, and postpartum women can be provided the care not available in the referring hospital. This is being done to help reduce severe maternal morbidity/mortality.[5]

These dual systems were developed, first for neonatal transfer and then maternal/fetal transport followed by an expansion of maternal transport (antepartum, intrapartum, and postpartum), to assist in the reduction of maternal and perinatal morbidity and mortality. The purpose of this study is to examine the evidence that has led to the development of a maternal transport system, the subsequent evolution and elements of that system and the maternal and perinatal outcomes resulting from a maternal/fetal and maternal transport system.

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Materials and Methods

A literature search was undertaken by our university librarian using the search engines PubMed, CINAHL, and Embase. The search terms used included "maternal transport" AND "perinatal care" OR "labor" OR "obstetric" OR "delivery". The years searched were 1960–2023. The only limitation was that the articles had to be in English. There were 266 articles identified. Four of the authors reviewed the abstracts for relevance to maternal transport and obstetrical care. The full articles of the identified relevant abstracts were read. Inclusion criteria for this review included articles that discussed levels of perinatal and obstetric care, need for transport, maternal transport, maternal outcomes, neonatal outcomes, reimbursement, and organization. The references of the selected articles were reviewed for additional applicable articles. There were 52 articles selected as the basis for this review (Figure 1).

Background / History of Maternal Transport

Maternal transportation has evolved in the United States in the past 50 years.[4] The first recorded use of an ambulance to transport a patient was in Chicago in 1899. The use of ambulances for maternal transport has developed into the use of multiple means of transportation including helicopters, fixed wing aircraft, and water vehicles. In 1986, the Emergency Medical Treatment and Active Labor Act was signed which requires any medical facility to provide emergency medical services and stabilization to any person with an emergency medical condition or any woman in labor.[6] Under this framework, obstetric transports must either be stabilized (eg, blood pressure non-severe in preeclampsia, category 2 or 3 fetal monitoring resolved, and stable vital signs in the setting of a patient with presumed sepsis) or the transferring provider must have significant concern that there would be harm in continuing care at the original facility.[6] This raises the question of which provider has ownership of the patient during transport. For this, there are two different strategies, one-way and two-way transports. In one-way transportation, the originating facility arranges for transport and maintains responsibility until the patient arrives at the receiving facility. In two-way transportation, the receiving facility arranges

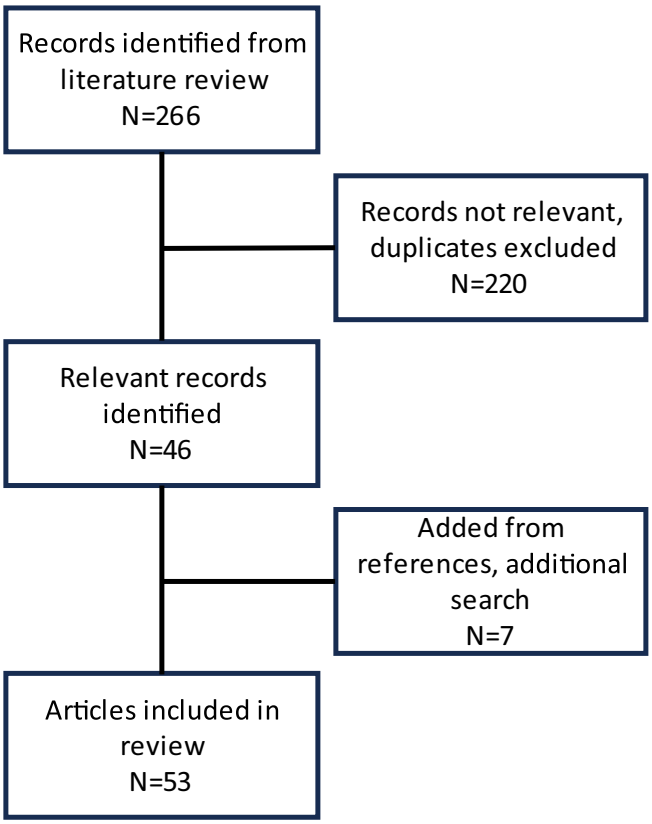

Figure 1 Literature Review.

for the patient to be picked up by their own transport team and is then brought to their facility. One-way transportation is the most common form, especially in rural states.[7] In two-way transportation, the receiving facility assumes responsibility once the patient leaves the original location.[7]

Maternal transport gives pregnant women the opportunity to receive care in the level of facility that best meets their needs.[4] Mothers are transported from home to a hospital or from hospital to hospital for a variety of reasons. The most common indications for transport between hospitals are pregnancy-induced hypertension, infection, and placentation.[8] To measure maternal outcomes, maternal mortality review committees (MMRCs) can use transport records to comprehensively assess pregnancy-related deaths.[4] Pregnancy-related death is defined as the death of a woman during pregnancy or within one year of the end of pregnancy from a pregnancy complication, a chain of events initiated by pregnancy, or the aggravation of an unrelated condition by the physiologic events of pregnancy.[4] In a retrospective study in Ohio from 2010–2016, the MMRC reported that transfer to a higher level of care might have improved the maternal outcome for 11% of all pregnancy-related deaths.[4]

A study from Canada showed that the use of magnesium sulfate in pregnancies <29 weeks with preeclampsia was administered over a shorter period of time, with improved outcomes attributed to maternal transport prior to delivery in 9.9% of cases.[9] Early transport with the initiation of treatment before transport to a tertiary hospital may reduce the maternal death rate as delays in receiving proper treatment for high-risk pregnancy conditions can result in maternal death.[9] In the case of postpartum hemorrhage, the physician needs to make an early decision regarding maternal transport if an emergency hysterectomy is indicated and unable to be done at the current facility.[10]

Transport delay can immensely impact maternal outcomes.[8] In a study in Jordan in 2012, 15.8% of cases of substandard maternal care were attributed to a delay in transport.[11] An improvement in the efficiency of the maternal acceptance process, and therefore decreasing time for maternal transport, will directly improve maternal and neonatal outcomes.[8]

The recognition of the value of a maternal transport system (antepartum – intrapartum – postpartum) evolved from the appreciation of the success from regionalization of perinatal care and the increasing rates of maternal morbidity and mortality in the US. The US maternal mortality rate increased from 17.4/100,000 in 2018 to 23.8/100,000 in 2020 and the rate in non-Hispanic blacks in 2020 was 55.3/100,000.[12] These rates are more than 3 times higher when compared with 12 other high-income countries (Netherlands, Australia, Japan, Germany, Norway, United Kingdom, Sweden, Switzerland, France, Canada, Korea, New Zealand). This has led to a determined effort to reduce maternal morbidity/mortality by regionalization of maternal care. The leading causes of maternal mortality are cardiovascular conditions, infections/sepsis, hemorrhage, cardiomyopathy, and non-cardiovascular conditions.[13] The maternal transport of these women to the appropriate level of care will increase the level of expertise and resources available to treat these women and hopefully will reduce morbidity and mortality as was observed with the regionalization of perinatal care.

Need for Transport System

Prior to the development of maternal transport in the 1960s, providers travelled to women's homes during and after labor if necessary.[6] With the development of neonatal intensive care units for specialized care of premature babies, low birth weights, and other abnormalities, maternal transport rates began to rise.[6] Today, 6% of all EMS calls are for an obstetric issue. It has been estimated that 15% of all pregnancies will encounter complications and 7% are serious enough to require transfer or referral to a higher level of care.[14] The most common reasons for transfer include preterm labor, OB hemorrhage, preeclampsia, and eclampsia.[6] There is an evident need for maternal transport systems as well as improved education on pregnancy-related conditions for EMS personnel.[7] Although there is a very small risk of deterioration during transport, EMS personnel need to be trained in the event that they do need to make life-saving interventions.[6]

In many studies, maternal transport has been shown to improve both maternal and neonatal outcomes as well as decrease the risk of serious morbidity and mortality. Lack of transport systems can lead to fatal delays.[14] In 2016, a study showed that only 30 of the 50 states, or about 60% of states, had maternal transport policies in place.[6,7] To improve outcomes, all states need to prioritize regionalized policies for maternal transport. Access to high-quality care during pregnancy and childbirth is a challenge for women in rural and remote areas due to shortages of childbirth providers.[7] For example, at Barnes Jewish Hospital in St. Louis, MO, the maternal transport team was dispatched in 1023 cases over

a 5-year period, and 48% of these patients were from medically underserved areas.[7] There is an urgent need for level IV care centers to develop a maternal transport program to assist in providing emergency care and stabilization upon arrival to a rural hospital.[7] Due to the long travel times from rural hospitals, an assessment for indications for maternal transport needs to be quick and thorough so that a transport order can be placed in a timely manner when it is indicated. Mothers who have to travel further to receive appropriate care have higher rates of infant mortality and NICU admissions.[7]

There is overwhelming evidence that it is more favorable to transport the maternal–fetal unit. Studies by Harris in Arizona, Chien from the Canadian Neonatal Network, Harris in Alabama, Menard in South Carolina, Levy in Louisiana, Modanlou in California, Bellini in southern Italy, Chen in Taiwan, Sasaki in Japan, Sachs in Georgia, Altimier in Ohio, and Kollee in the Netherlands among many others have all shown neonatal benefits from maternal transport.[15–26] Specifically, Harris, Chien, Harris, Menard, Chen, Kollee, Sachs, and Altimier found that neonatal mortality was decreased with maternal transport when compared to neonatal transport with odds ratios ranging from 1.6 to 2.6. Chien and Sasaki found decreased rates of interventricular hemorrhage in neonates born in tertiary care centers compared to transported neonates with one odds ratio reported of 1.49.[17,24] Chien, Harris, Kollee, and Modanlou found statistically decreased rates of neonatal respiratory morbidity in those transported prior to delivery as well, although odds ratios were not reported.[17,18,20,23] Harris, Modanlou, and Levy found neonatal length of stay was reduced in those transported prior to delivery. However, in the case of Levy's study, this was not statistically significant.[18,21,23] All of these studies indicate that transport of neonates after delivery bears significant risk for the infant and can worsen outcomes[15–24] (Table 1). When premature labor is imminent, women must be transported to tertiary hospitals with a NICU.[27] Fortunately, for long-term survivors, studies by Kollee and Sasaki showed few differences in long-term outcomes.[24,28] Kollee et al followed these neonates through 5 years of life and found no statistical differences in the rate of serious disabilities or handicaps.[28] Sasaki et al followed their cohort for 3 years and found no differences in rates of cerebral palsy, visual or hearing impairment, or neurodevelopmental delay, but there was a statistically significant difference in the rate of cognitive impairment (aOR 1.496, CI 1.015–2.203).[24] However, the increasing morbidity and mortality rates certainly point to a benefit of delivery at a hospital with a high-level NICU.

A study from California looked at the frequency of very low birth weight (VLBW) births at non-level III hospitals. This study performed a retrospective cohort analysis looking at birth certificates and discharge data from 2008 to 2010 deliveries with birth weight 400–1500g. They found that, overall, only about 15% of VLBW neonates were born at non-Level III (neonatal) hospitals. However, in many of those cases, the maternal admission was >24 hours in which maternal transport may have been possible. For instance, at Level II hospitals of the 905 that were born with VLBW, 20% had an antepartum length of stay (LOS) of at least 24 hours and 27% had LOS 48 hours or greater prior to delivery. Level I hospitals were more apt to send patients to tertiary care centers sooner, with only 17.5% of patients having an LOS greater than 24 hours and only 14% having an LOS greater than 48 hours.[29] Emergency maternal transport services are essential to improving maternal outcomes and mitigating the extent to which lack of transport is a barrier to utilizing health services, thereby decreasing morbidity and mortality rates.[30] In a study from Uganda, a free-of-charge, reliable 24-hour transport service for mothers increased access to and utilization of obstetric care services when compared to neighboring regions. They found a 50% increase in hospital deliveries overall and a 100% increase in the cesarean section rate simply due to reliable transportation services.[31] In addition, maternal transport on average is easier and less expensive than neonatal transport.[1]

One area of obstetric transport that needs more study is the need for continuous fetal monitoring during transportation. Currently, there are no standardized protocols for fetal monitoring during obstetric transportation.[32] Studies have shown that continuous cardiotocographic monitoring is certainly possible during transportation.[32,33] However, it is uncertain if continuous monitoring and periodic interpretation of EFM affects fetal outcomes.

Mode of Transportation and Transportation Personnel

Maternal transport can occur in a variety of vehicles but can be ultimately categorized into 3 basic modalities: ground, water, and air. Of these, ground and air are traditionally the most common.[34] Water transport is typically used in specific geographic locations, such as in the Japanese archipelago where smaller islands may not have the capability to support air transport.[35] The first recorded use of an ambulance in the United States was in Chicago in 1899. Although transportation

Table 1 Neonatal Benefits of Maternal Transport

Study	State/Country	Year(s)	Conclusions
Harris, T[19]	Arizona	1974–1976	Neonatal mortality risk was lower for maternal transport than for neonatal transport in almost all groups compared, but it was statistically significant in Colorado neonatal mortality risk groups F, G, and H (the highest risk groups). Maternal transport was associated with only 22.6% mortality compared to 41.0% for neonatal transports in the same groups ($p<0.05$).
Chien[17]	Canada	1996–1997	Outborn infants were at statistically higher risks of death (9% vs 16%), grade III or IV IVH (7% vs 17%), PDA (19% vs 26%), RDS (48% vs 79%), and nosocomial infection (15% vs 26%).
Harris, B[18]	Alabama	1975–1977	Compared in utero referrals to neonatal referrals to a Level III NICU. Found statistically lower rates of neonatal mortality ($p<0.0001$) and statistically lower rates of positive pressure ventilation (CPAP $p<0.0005$, IPPV $p<0.0001$). In addition, length of hospital stay was found to be shorter in the in utero referrals (13.2 days vs 20.4 days, $p<0.0001$).
Menard[22]	South Carolina	1993–1995	Compared neonatal survival rates of VLBW infants by hospital perinatal level of care. 79% of VLBW deliveries occurred at Level III centers, but neonates born at level I and level II centers had an adjusted relative risk of mortality of 1.67 (CI 1.45–1.91).
Levy[21]	Louisiana	1978–1979	Compared mortality rates and NICU length of stay in infants transported before and after delivery. Found slightly higher survival rate (90% vs 87%) and a shorter LOS (11.8 vs 21.4 days). However, neither was statistically significant.
Modanlou[23]	California	1978–1979	Neonates transported prior to delivery had lower incidence of RDS and shorter hospitalizations.
Bellini[15]	Southern Italy	1998–2014	Analyzed the effect of a regional transport service on the number of inborn VLBW infants and overall mortality rate in the region. During the study period there were statistically significant increases in inborn VLBW infants ($p=0.002$) and in overall infant mortality rates ($p=0.001$).
Chen[16]	Taiwan	2011–2016	Compared neonatal mortality rates between those born at a tertiary care center and those born elsewhere and transferred to a tertiary care center. Inborn infants had a mortality rate of 0.39% compared to 2.05% for outborn infants which was statistically significant.
Sasaki[24]	Japan	2003–2011	Compared inborn vs outborn extremely preterm infants. Found increased risk of severe IVH (aOR 1.49, CI 1.11–2.00), NEC (aOR 1.49, CI 1.11–2.00), and focal intestinal perforation (aOR 1.58, CI 1.09–2.30). Follow up at 3 years of life also found a higher risk of cognitive impairment (aOR 1.49, CI 1.01–2.20).
Kollee[20]	The Netherlands	1983	Found the odds ratio for neonatal mortality to be significantly lower in infants born after maternal transport to a tertiary care center when compared to infants delivered at local hospitals. (OR 0.4, CI 0.18–0.83) Also found significantly lower rates of RDS (OR 0.36, CI 0.20–0.65)
Sachs[26]	Georgia, USA	1974–1978	The relative risk of neonatal mortality was higher for a neonate born at a primary center and transported to an NICU than those born at a tertiary center and admitted directly to an NICU. (RR 1.6, CI 1.5–1.8)
Altimier[25]	Ohio	1999–2000	~60% of VLBW infants born at sites without a NICU required transport to a level III center. Neonatal transport was associated with a 2.6 times higher risk of death or major morbidity. (aOR 2.64, CI 1.7–4.17)

by ambulance has been available for many years, modern medical transportation was not available until the 1960s.[6] In 1973, the EMS Services Development Act led to the development of a comprehensive national EMS system.[6] Today, the office of EMS is under the Department of Transportation and the National Highway Traffic Safety Administration. In addition, the Commission on Accreditation of Medical Transport Systems has become the main accreditation body for EMS. While it started as an independent nonprofit organization that provided this service on a voluntary basis, many state regulatory bodies now require it to obtain a license to operate.[6]

In the United States, the most common mode of maternal transportation is via ground transport.[7,36] Ground transport can further be broken down into classifications based on the services individual ambulances are able to provide. Basic life support ambulances provide staff and monitoring for the transfer of patients with non-life-threatening conditions.[34] Advanced life support ambulances can provide additional services such as intubation, cardiac monitoring, IV infusions, and defibrillation if needed. They are used for patients requiring a higher level of care throughout the transport process.[34] Mobile intensive care units are reserved for patients who are critically ill. These ambulances are typically staffed by specialized retrieval teams with advanced equipment.[34] Occasionally, private automobiles may be used to transport a patient to another facility, but this is generally discouraged due to either maternal–fetal instability or the possibility of unattended delivery during transport.[37] One of the main benefits of ground transportation is cost. In a study of over 1000 women who required emergency transportation, Vitalia and Troeger found that the cost of ground transport averaged about $850, while the cost of air transport was close to $23,000.[36] Additionally, ground transportation has relatively few weather constraints, unlike air transportation. In general, ground transportation is usually appropriate, even in rural settings. However, if ground transport is not technically feasible or there is a high risk fetal or maternal condition requiring immediate treatment, air transportation may be employed.[38]

The first use of an airplane as an air ambulance to transport patients to the hospital occurred not long after the first air flight by the Wright brothers.[39] During World War I, the British used a biplane to quickly move injured service men out of Turkey to a hospital, taking 45 minutes compared with 3 days over land. This started the modern era of using aircraft with specialized crews to transport patients to hospitals where care could be provided. This has now evolved to transport from scenes of accidents to hospitals or transfers between hospitals from lower levels to higher levels of care.[39] There are two main types of air transport: fixed wing or airplane ambulances and rotor wing or helicopter ambulances. In general, rotor-wing ambulances are used for transports within about 100 miles, and helicopters can usually take off and land at or near the facilities necessary.[38] Fixed-wing ambulances may be employed for long-distance transports, typically >100 miles. One drawback to this form of transportation is that it requires ground transport to and from local airports, adding additional medical transportation requirements. However, they have fewer weather constraints when compared to helicopters.[38]

In addition to the mode of transportation, the expertise of the transporting staff must be sufficient to administer appropriate care in the event of an emergency. Each patient may be assigned a level of critical care dependency, which guides the required personnel needed for transportation. Level 0 indicates a patient who can be managed without specialized personnel. Level 1 indicates a patient who is at risk of declining status but can be adequately managed in an acute ward setting with support from a critical care team. These patients are typically accompanied by trained paramedics and/or nurses. Level 2 patients require close observation or even intervention due to the high risk of organ system failure. Specialty trained personnel are required in these situations. The final group, level 3 patients, require advanced respiratory care and management of ongoing organ system failure throughout transport. These patients are typically accompanied by a specialty physician in addition to trained nurses and/or paramedics.[34]

It appears that medical transport is safe for pregnant women and even those in active labor. However, the gestational age of the fetus, the capabilities of the referring hospital, the expertise of the transporting health care providers, and the distance and time to travel all must be taken into consideration when deciding the mode of transportation.

Births Before Arrival

One of the main concerns regarding maternal transport is the possibility of delivery during transport to the receiving facility. Births before arrival have been associated with higher rates of postpartum hemorrhage for maternal patients and increased risk of hypothermia and hypoglycemia for neonates. Neonates are also much more likely to require additional care in either a specialized nursery or a neonatal intensive care unit.[40] A retrospective analysis of the Queensland Ambulance Service in 2010–2011 showed 5722 women transported to a hospital with contractions or ruptured membranes as their chief complaint. Of those, only 356 delivered under paramedic care.[41] A retrospective study from Australia evaluated ambulance calls for laboring women in Victoria.[42] During that time period, there were 1517 calls for transport for laboring women greater than 20 weeks of gestation. The majority were at term (2/3). Of the 1/3 that were

preterm 40% were less than 32 weeks gestation. There were 134 pregnancies which progressed to delivery while under the care of paramedics.[42]

One of the earlier reports in the OB/GYN literature was a survey by the American Society of Hospital-Based Emergency Air Medical Services to determine inflight deliveries and associated perinatal mortality.[43] They found no in-flight deliveries from 375 helicopter transports; 315 of the women were in active labor and 72 in the active phase of labor. There was one delivery in 88 fixed wing airplane transports. Another study evaluated "to fly" or "not to fly" with advanced cervical dilation.[44] This study evaluated 1080 patient transfer calls due to preterm labor, 54 of which were ≥7 cm dilated. Of those 54, five were delivered at the referring hospital before transport. The other 49 were successfully transferred before delivery, and only 21 of those pregnancies delivered within the first hour of arrival. The rarity of births during transport is highlighted in another study from Australia. A retrospective observational study of 500 consecutive flights by the Royal Flying Doctor Service from rural Western Australia to Perth by fixed wing aircraft had no in-flight deliveries or complications associated with the transfer.[45] Factors that were associated with shorter time from landing to delivery included cervical dilation ≥4 cm, gestational age >32 weeks and nulliparity. A smaller study of 26 pregnant women by helicopter in Japan had no patient who developed any complications during flight.[46] A review of in-flight deliveries in Finland revealed one in a fixed wing aircraft in 1939 and a breech delivery in a helicopter in 2013.[47] There was no information on how many pregnant women were transported by air in Finland between 1939 and 2013. A 2-year assessment of air transport of obstetrical patients to Halifax Nova Scotia documented 121 flights with no in-flight deliveries.[48] Another 2-year study evaluated 80 fixed wing obstetrical transports and no in-flight deliveries occurred.[49]

Due to the risk of birth before arrival, it is imperative that medical transport teams have knowledge about antepartum and intrapartum care and the clinical skills to assist with complications that can occur with deliveries. A study from Sweden emphasized the importance of the demeanor of the transport nurse if the delivery were to occur outside of the hospital during transport. The nurse must remain calm and reassuring no matter what the situation looks like, listening to the mother, and meeting her needs.[50] Another Swedish study emphasized the importance of specialist nurse education and training, including scenario training to help prepare the nurses to manage the patient and assist in delivery if that occurs during transport[51] (Table 2).

Levels of Care

When a provider determines that transport of a mother and fetus is needed, it is important to know which nearby facilities can meet the needs of the patient.[52] This starts with having a designation for hospitals that can care for pregnant patients with various risk factors. Historically, these levels of care surrounded the eventual care of the neonate. In the 1970s,

Table 2 Deliveries Enroute by Mode of Transport

Study	Country	Years of Study	Mode of Transport	Number of Patients Transported	Number Delivered Enroute
Flanagan[41]	Australia	1/2010-12/2011	Ground	5722	356
McLelland[40]	Australia	1/2009-12/2009	Ground	1517	134
Low[43]	U.S.	1988	Air	357	0
Elliott[44]	U.S.	1/1989 – 9/1990	Air	1080	0
Akl[45]	Australia	9/2007-12/2009	Air	500	0
Ohara[46]	Japan	8/2005 – 7/2006	Air	26	0
Pulkkinen[47]	Finland	1939–8/2013	Air	No data	2
Jony[48]	Canada	1/2003 – 12/2004	Air	121	0
O'Brien[49]	U.S.	7/2000 – 6/2002	Air	80	0

neonatal levels of care were developed, and these largely dictated transport of pregnant patients with an eye to care of the neonate should delivery be required.[53] However, this left a gap in the care of maternal conditions that may not necessarily require delivery. Therefore, in 2015, The American College of Obstetricians and Gynecologists and the Society for Maternal Fetal Medicine issued a joint care consensus document intended to develop standards for designations of levels of maternal care (LOMC) that are complementary to, but distinct from, neonatal levels of care. The document has uniform definitions that provide a standardized description of a facilities' capabilities and personnel specific to providing maternal care.[5] These LOMC are Accredited Birth Center, Level I (Basic care), Level II (Specialty care), Level III (Subspecialty care), and Level IV (Regional Perinatal Health Care Centers). The differences in these levels of care are summarized in the accompanying table, but each additional level has requirements regarding on-site and/or readily available obstetric providers in addition to facility capabilities such as intensive care units, imaging modalities, and specialized consultants[5] (Box 1).

State governments have also been involved in this push to establish LOMC. These state guidelines have been in conjunction with efforts to decrease maternal mortality. Tennessee was one of the first to adopt LOMC and transport guidelines in 1977, when they expanded their perinatal transport system to include obstetrics.[37] However, there are still many states that have not codified requirements for LOMC. A 2020 study compiled data from 50 U. S. state websites to identify whether they had guidelines for levels of maternal care. Only 17 states had LOMC guidelines identified. Requirements for levels of care vary by state, but there are some common elements. To be considered a Level

Box 1 Maternal Levels of Care (Adapted from[5])

Accredited birthing center

- Able to provide care to low-risk women with uncomplicated singleton term vertex pregnancies expected to have an uncomplicated birth

Level I (Basic Care)

- May provide care to low- to moderate risk pregnancies with the ability to detect, stabilize, and initiate management of unanticipated maternal-fetal or neonatal problems until the patient can be transferred
- Capable of providing
  - Emergency cesarean section
  - Limited obstetric ultrasound and interpretation
  - 24-hour laboratory and block bank
  - Implement maternal safety bundles
  - Initiate massive transfusion with a process to obtain more blood and components when necessary
- Health care providers available
  - Every birth attended by a qualified birthing professional and appropriately trained and qualified RN
  - Physician with privileges to perform emergency cesarean at all times
  - Primary maternal care providers
  - Trained and qualified RNs
  - Anesthesia providers (maybe anesthesiologist, nurse anesthetist, or anesthesiologist assistants)

Level II (Specialty Care)

- Level I plus the ability to care for additional high-risk conditions
- Capable of providing
  - Advanced imaging (computed tomography scan, magnetic resonance imaging, non-obstetric ultrasound, and maternal echocardiogram)
    - Does not need to be 24h access, but at least daily access
  - Standard obstetric imaging at all times
- Health care providers
  - Ob/Gyn readily available at all times
  - MFM readily available at all times for consultation (phone and/or telemedicine is acceptable)
  - Anesthesiologist available at all times
  - Medicine physicians and general surgeons readily available for obstetric patients

(*Continued*)

Box 1 (Continued).

Level III (Subspecialty Care)

- Level II plus the ability to care for more complex maternal and fetal conditions as well as complex obstetric complications
- Capable of providing
  - In-house availability of all blood products
  - Advanced imaging readily available at all times
  - Specialized obstetric ultrasound (including Doppler studies) with interpretation at all times
  - Basic interventional radiology (specifically for uterine artery embolization)
  - Equipment and personnel onsite to ventilate and monitor women on L&D prior to transfer to ICU
  - Ability to accept and facilitate maternal transports
- Health care providers
  - Nursing with special training and experience in complex and critical illnesses and complications
  - Ob/Gyn physically present at all times
  - MFM readily available at all times (must be available for onsite consultation in critical situations, must be able to provide direct care within 24 hours in most situations)
  - Anesthesiologist physically present at all times
  - Full complement of subspecialists readily available for inpatient consultation

Level IV (Regional Perinatal Health Care Centers)

- Level III plus on-site medical and surgical care of the most complex maternal and fetal conditions throughout gestation
- Capable of providing
  - On-site ICU care for obstetric patients with primary or co-management with MFM
- Health care providers
  - MFM team with expertise in highly complex, critically ill, or unstable patients available at all times for consultation and management
  - Continuous availability of RNs with experience in the care of women with complex medical illnesses and obstetric complications
  - Anesthesiologist with obstetric anesthesia experience physically present at all times
  - Neurosurgery, cardiac surgery, and transplant subspecialists readily available at all times or a process in place to transfer to a facility that does have them.

I center, most states require obstetric providers available to attend each delivery, availability of labor and/or surgical anesthesia, the ability to perform an emergency cesarean section, a blood bank, and a transport and referral system in place for high-risk conditions.[52] Highest LOMC designations (either Level III or IV depending on the state) require additional resources including maternal fetal medicine availability, subspecialty consultations (including neonatology), and ICU availability, among other requirements.[52] Lack of LOMC guidelines across the country limits monitoring and evaluation of regionalized systems of maternal care.

In addition to guiding maternal transport, LOMC may be able to help guide where patients receive their prenatal care. Using LOMC to facilitate early consultation or referral to higher-level centers when deemed necessary would direct patients to risk-appropriate care earlier in pregnancy. This would theoretically reduce maternal transports, optimize resources, and improve outcomes.[8] A study by Koguttet al examined 652 maternal transports from Sept '15–Jun '19 to either Johns Hopkins Hospital (a Level IV center) or JH Bayview (a Level III center). They recorded the indication for transport as well as the LOMC provided by the referring hospital. The most common reason for transport was hypertensive disorders of pregnancy across all referring centers. Centers with no labor and delivery units most commonly transported for things like abdominal pain, infection, nausea and vomiting, and maternal trauma or assault and were the least likely to deliver during the admission following transport. Level I and level II care centers tended to be further from the transport destination and were also more likely to employ air transportation. It was determined that approximately 20% of transports were potentially preventable if care had been initiated at a risk-appropriate level of care sooner in the pregnancy.[8]

Maternal Transport Checklist

Transport of a high-risk pregnant patient is a complex process that requires patient handoff between 3 different care teams. The referring provider, the medical transport team, and the accepting provider must all have accurate information regarding the patient's status to provide adequate care for both the mother and fetus. Communication errors during patient checkout are among the leading causes of patient harm, so, to help simplify the process, SMFM created a sample Maternal Transport Briefing Form and Checklist to aid in providing a relatively comprehensive and concise format for communication.[54] The form is meant as a guideline that should be adapted by receiving facilities to elicit what services will be needed once the transport is completed. A summary of critical information to be provided is in Box 2. In general, a detailed description of the patient's current diagnosis as well as overall pregnancy complications should be discussed. Any fetal concerns should be addressed. A review of the patient's vital signs and a recent cervical exam should be documented if relevant to the patient's complaint. Any recent fetal ultrasound results should be discussed including the presenting fetal part. If possible, an assessment of external fetal monitoring and tocodynamometry should be performed. Any medications and/or transfusions given to the patient prior to or during transport should be documented. The mode of transportation should be discussed along with a discussion of whether any maternal or fetal monitoring will be done enroute. Finally, a plan should be in place to have any hospital and/or clinic notes sent to the receiving facility[54] (Box 2).

Policy for Reimbursement and Organization

Obstetric transport programs along with the regionalization of maternal and neonatal care can have robust benefits on both maternal and perinatal morbidity and mortality, but this necessitates the structure and organization of a regional

Box 2 Transport Briefing and Checklist

Transport Briefing and Checklist (Adapted from[54])

- Patient identifying information (Name, DOB, MRN, etc.)
- Receiving hospital and contact information
- Date and time of initial call, when transfer was accepted, and when the patient left the sending facility
- Gravidity, Parity, EDD, Gestational age (or date of delivery)
- Indication for transfer
- Primary and secondary diagnoses
- Pertinent medical and surgical history
- Advanced services needed on transfer (ie, ICU, cardiac, NICU, etc.)
- Referring physician and primary obstetrician
- Accepting physician
- Vital signs
- Vaginal exam
- Membrane status
- Vaginal bleeding
- Fetal ultrasound findings (Presentation, placentation, EFW, etc.)
- Pertinent labs
- Assessment of external fetal monitoring
- Medications given
- Blood products given
- Mode of transportation
- Monitoring during transportation
- Document checklist
  - How are they being sent?
  - Prenatal records, labs, ultrasound reports
  - Current labs, H&P, relevant notes, EFM strips, etc.
  - Transfer consent

transport network to aid in getting patients where their needs are best met. DeSisto et al looked at individual state policies regarding maternal and neonatal transport as well as policies on the reimbursement for these transports either by a funded state program or mandating reimbursement by insurance companies, including Medicaid. They found that 42 states have neonatal transport policies compared to only 37 states with codified maternal transport policies. However, policies for the reimbursement of these transports are much more lacking. Only 31 states have policies on reimbursement for neonatal transport, and only 11 had policies on maternal transport reimbursement as of 2019. Thirty states do have policies on Medicaid reimbursement.[55] Given the advances in regionalized and specialized care and the benefits of maternal transport to these centers, codified policies regarding state-level transport and reimbursement should be ubiquitous.

Conclusions

Maternal, neonatal, and maternal/fetal transport has evolved significantly since the first use of an ambulance to transport a patient in 1899 into a sophisticated system using ground transportation, air transportation, and water transportation. Both maternal and neonatal care outcomes have improved with a decrease in both morbidity and mortality. The ideal transport for the best neonatal outcomes in preterm pregnancies is the transfer of the fetus in-utero. Although there is concern for birth before arrival using medical transportation, there are relatively few reported cases of this occurring. The development of a system for maternal transport to a facility best suited to meet their needs has significantly reduced maternal morbidity/mortality. The development of levels of care for both maternal and neonatal care has expanded and promoted the transfer where the appropriate level of care can be delivered.

All of these advances and policies have contributed to the development of a robust system with clear guidelines that help guide local providers in transferring patients to the proper institutions with the appropriate level of care. Designations of maternal and neonatal levels of care have led to increased regionalization of care and the development of specialty centers that excel in the care of complex maternal and neonatal conditions. By sending patients to centers that have all the resources necessary for ongoing care of the maternal–fetal unit, we create a system in which these regional centers provide a safety net that has helped to address maternal and neonatal morbidity over time. These regional centers help to support the entire medical system under their wing by providing a safety net in the form of a safe place to transport patients, by providing training and teaching to local providers and care teams in the initial treatment and stabilization in obstetric emergencies, and by offering consultative services to hospitals that may not have providers comfortable in the care of the pregnant patient. However, this comes with its own set of limitations. Regional specialization creates scenarios in which smaller hospitals no longer retain the ability to care for maternal-fetal units on a regular basis. This decreases access to quality local healthcare, especially in rural settings. In addition, emergency care must be provided by providers without comprehensive or consistent training in obstetrical emergencies. While consultations are available via phone or teleconference, some situations may benefit from immediate care from specialized providers instead of requiring an inexperienced or ill-equipped provider to initiate care while waiting until appropriate resources are available via transportation.

Policy makers across the country should strive to have detailed and comprehensive guidelines outlining the levels of maternal care requirements in their states or communities. There should be policies in place regarding reimbursement for maternal transport. Smaller hospitals should work with tertiary and quaternary centers to educate their emergency staff about the most common obstetric and neonatal emergencies so they can adequately stabilize patients prior to transportation. Local hospitals should create easy-to-follow workflows to facilitate transport to higher levels of care in the most efficient manner possible. Institutions with higher levels of care should strive to make the consultative process streamlined and efficient to help smaller hospitals when the need arises. All these things will create a safety net within our systems to catch as many patients as possible and improve outcomes for both the mother and the neonate.

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