A SYNTHESIS PAPER ON ELECTRONIC HEALTH RECORDS AND THE BARRIERS TO THEIR IMPLEMENTATION IN THE NEONATAL AND PEDIATRIC TRANSPORT TEAM ENVIRONMENT

By

C. Tony R. Hampton

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C. Tony R. Hampton

"A SYNTHESIS PAPER ON ELECTRONIC HEALTH RECORDS AND THE BARRIERS TO THEIR IMPLEMENTATION IN THE NEONATAL AND PEDIATRIC TRANSPORT TEAM ENVIRONMENT"

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Vishnu Mohan

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LIST OF ABBREVIATIONS

AAP	American Academy of Pediatrics
AAP SOTM	American Academy of Pediatrics Section on Transport Medicine
ACOG	American College of Obstetricians and Gynecologists
ALS	Advanced Life Support
BLS	Basic Life Support
CDC	Centers for Disease Control and Prevention
CINAHAL	Cumulative Index to Nursing and Allied Health Literature
CRRT	Continuous Renal Replacement Therapy
dB	Decibel
EBSCO	EBSCO Host Databases Services (Elton B Stephens Company)
ECMO	Extracorporeal membrane oxygenation
ED	Emergency Department
EHR	Electronic Health Record
EMR	Electronic Medical Record
EMS	Emergency Medical Service
EMSTARS	EMS Tracking and Reporting System
EMT	Emergency Medical Technician
EMT-B	Emergency Medical Technician-Basic
EMT-P	Emergency Medical Technician-Paramedic
ePCR	Electronic Patient Care Record

LIST OF ABBREVIATIONS (CONTINUED)

FAAP	Fellow of the American Academy of Pediatrics
FIO2	Fraction of Inspired Oxygen
FN3	Florida Neonatal Neurological Network
HIE	Health Information Exchange
HIPAA	Health Insurance Portability and Accountability Act
HFJV	High Frequency Jet Ventilators
HFOV	High Frequency Oscillator Ventilators
HL7	Health Level 7
iNO	inhaled Nitric Oxide
ICU	Intensive Care Unit
ILCOR	International Liaison Committee on Resuscitation
INPC	Indiana Network for Patient Care
IOM	Institute of Medicine
IT	Information Technology
NEMSIS	National Emergency Medical Services Information System
NPT	Neonatal Pediatric Transport
NICU	Neonatal Intensive Care Unit
PaO2	Arterial partial pressure of oxygen
PEEP	Positive End Expiratory Pressure
PICU	Pediatric Intensive Care Unit
PIP	Peak Inspiratory Pressure
PRISM	Pediatric Risk of Mortality

LIST OF ABBREVIATIONS (CONTINUED)

RHIO	Regional Health Information Organization
RN	Registered Nurse
RT	Registered Therapist
SRM	secure and reliable messaging
VistA	Veterans Health Information Systems and Technology Architecture
%SVO2	Mixed venous saturation of oxyhemoglobin

ABSTRACT

In 2011, almost 4 million babies (Hamilton, Martin, and Ventura 2011) were born in the United States, with approximately 12% of those being premature (Hamilton, Martin, and Ventura 2011). About 10% of newborns require some form of resuscitation to begin breathing at birth with about 1% requiring extensive resuscitation effort to survive (ILCOR 2006). Karlsen *et. al.* (2011) reported the median neonatal transport volumes of as many as 68,797 critically ill neonates being transported each year in the United States. These transports require a coordinated effort with highly trained personnel, specialized equipment and ambulances. There are also more than 8.7 million children and teenagers who were treated for an injury in United States Emergency Departments and more than 225,000 of these children had injuries serious enough that required hospitalization or transfer to another facility with a higher level of care (CDC 2012). Pediatric visits account for about 27 percent of all visits to emergency departments in the United States (IOM 2010). About one percent of children who visit Emergency Departments are transferred to another facility for a higher-level of care (IOM 2007). Specialized neonatal/pediatric transport teams are trained to deal with specific needs of this unique population and have the equipment and expertise necessary to bring essential therapies usually only provided at the tertiary facility to the bedside at the referring facility and community emergency departments.

Many Emergency Medical Services (EMS) have developed an electronic medical record, which is usually called an Electronic Patient Care Report (ePCR). The ePCR is similar to an electronic medical record (EMR), but has documentation streamlined for the pre-hospital situations and other aspects that are not found in commercial EMRs. Most neonatal and pediatric specialized transport teams are part of children's hospitals and have close connections with local EMS providers that utilize ePCRs. It is because of this camaraderie that some of the neonatal and pediatric specialized transport teams have adopted their local EMS provider's ePCR as their electronic health record for their documentation need while on these neonatal and pediatric transports.

One specific article that looked at implementation of electronic medical records in the pre-hospital setting (Landman *et. al.* 2012) used in-depth interviews with key informants. The 20 EMS agencies surveyed by Landman *et.al.* (2012) do adult EMS transports and made no mention of neonatal or pediatric transports. Landman *et. al.* (2012) came up with four themes: financial, organizational, technical and privacy/security. In this synthesis paper, we will explore the barriers to implementation of an electronic health record in the neonatal and pediatric transport environment as they relate to the unique and demanding conditions seen on neonatal and pediatric critical care transports.

BACKGROUND

There are many barriers to implementation of an electronic health record in a prehospital care environment. Landman *et. al.* (2012) listed four themes: financial, organizational, technical, and privacy/security. The organizational aspect of transport is complex and requires explanation, in order to gain a true understanding of the plethora of problems that can occur when trying to implement an electronic medical record.

The prehospital care environment is one with Emergency Medical Services providing out of hospital emergency care to patients with bodily injuries and medical emergencies. When a patient calls 9-1-1, EMS responds, patient is transported to closest ED and EMT gives handoff to ED staff. This system works well for adult patients. However, many hospitals are not well prepared to handle pediatric patients, with only about six percent of Emergency Departments in the United States having 100 percent of the supplies deemed essential for managing pediatric emergencies and only 50 percent of the Emergency Departments have at least 85 percent of those pediatric supplies deemed essential (IOM 2007). In addition, pediatric skills can deteriorate quickly without practice, but continuing education in pediatric care is not required or is extremely limited for many prehospital emergency medical technicians (EMTs) (IOM 2007).

A neonate is defined as a newly born child, or one that is up to 28 days of life (ACOG 2012). An infant is defined as a child between ages of 28 days of life and 1 year of age (ACOG 2012). Pediatric patients are usually from 1 year of age to eighteen years of age. Specialized neonatal only, pediatric only, and neonatal and pediatric transport teams are found throughout the United States and in other countries. These teams are usually run out of either a local children's hospital or as a result of a partnership between local hospitals, EMS providers, and healthcare businesses that cover the expenses of such specialized care. They are usually not part of the Emergency Medical Services system, but partner with many key players within the EMS system. These specialized teams transport some of the sickest and most critical patients from a referring hospital to tertiary care centers because these patients need therapies not available at the referring hospital. These transfers require extensive coordinated efforts between referring and accepting facilities, along with specialized equipment, ambulances, and transport personnel with advanced training, which are able to deal with the critical, fragile and unique needs of this patient population.

Specialized neonatal/pediatric transport teams are able to bring essential therapies usually only provided at the tertiary facility to the bedside at the referring facility and community emergency departments. A recent survey (Karlsen 2007 and Karlsen *et. al*. 2011) describes the workforce of the Neonatal Transport Teams. These teams consist of usually three to four team members per transfer with a Registered Nurse (RN), Registered Therapist (RT) with an

Emergency Medical Technician (EMT) driver being the most common (Karlsen *et. al.* 2011). They can also have other team members such as: Neonatologist, Neonatal Nurse Practitioners, Registered Nurses, Respiratory Therapist, Physician Assistants, EMT-Paramedics and EMT-Basic or EMT-Intermediate in many different configurations dependent on patient's needs and hospital logistics. Karlsen *et. al.* (2011) found that teams were either dedicated (meaning transport team members only worked on transports) or unit-based (meaning they were generally nurse or respiratory therapists that were pulled off a patient assignment in the NICU or PICU to go on a transport to pick up another NICU or PICU patient). These transport teams have wide variations in length and breadth of orientation, use of protocols and quality improvement. Use of protocols were more common in dedicated teams who usually did more transports, and may make it easier for them to transition to electronic health records and computerized provider order entry. Many specialized transport teams transfer both neonates and pediatric patients, while there are some who only transport neonatal patients or those who only transport pediatrics patients (Karlsen 2007) depending on the volume and specific logistics of the parent organization. Most neonatal transport teams will typically engage in interfacility transports from one hospital newborn nursery or NICU to another accepting facility's NICU. They occasionally may participate in an interfacility transport from a hospital's emergency department to their NICU.

The breadth and depth of areas of expertise and interactions is much greater with the specialized pediatric transport team than the neonatal transport team, a factor that is important when looking at interoperability with electronic health records. The specialized pediatric transport team will go to community emergency departments, community pediatric wards, community PICUs and community pediatrician's offices to transfer a critically ill child to their children's hospital. The specialized transport teams also enter data either by hand or electronically into the National Emergency Medical Services Information System (NEMSIS; Dawson 2006). The NEMSIS has a uniform national EMS dataset with standard terms, definitions, and values (Dawson 2006).

While the NEMSIS (NEMSIS 2013) is a good system and most states input data into this system, they input data on different time frames from as often as every two hours to as long as once a month (Ely *et. al*. 2006) and depending on the state, they can capture about half of the EMS calls or all of the EMS calls. Specialized transport teams are not traditionally thought of as EMS providers, but they still enter data into the NEMSIS. The NEMSIS data elements may not cover many pediatric aspects of transport and very few dealing with neonates (Florida EMS Data Dictionary 1.4 2013). In Florida, any EMS agency submits data to the Florida's Prehospital EMS Tracking and Reporting System (EMSTARS 2013), which then submits the data to NEMSIS. The ePCR solutions and vendors have to be EMSTARS Compliant (EMSTARS 2013), which could be a financial barrier

depending on how expensive it is to be EMSTARS Compliant in the state of Florida.

Specialized transport teams are important for the well-being of critically ill children. Orr *et. al*. (2009) did a single-center, prospective, cohort study that compared transports of 1,085 infants and children from referral community hospitals to their children's hospital. They compared their children's hospital specialized pediatric transport team to local EMS providers who have pediatric experience. Pediatric transports would come into the children's hospital PICU either by local EMS providers or their specialized pediatric transport team. The pediatric patients were scored using The Pediatric Risk of Mortality (PRISM) score, which is a standard score for PICU patients for severity of illness (Pollack, Ruttimann and Getson 1988) when they would arrive to the PICU either by the specialized pediatric transport team or the local EMS providers. This study showed that pediatric patients who were transported by the specialized pediatric transport team had improved survival rates and fewer adverse events compared to the local EMS providers, regardless of the severity of illness (Orr *et. al.* 2009).

> "*Children transported by nonspecialized teams had >2 times greater odds of death than did those transported by a specialized team, controlling for illness severity and other transport covariates*." (Orr *et. al*. 2009).

These specialized transport teams again are usually staffed by registered nurses and respiratory therapists according to Karlsen *et al*. (2011). This becomes vitally important because the barriers in implementation of an electronic health record may be related to how workflow changes are perceived by a nurse or respiratory therapist. Landman *et. al*. (2012) noted that EMT providers were concerned about how going to an ePCR would affect their workflow and whether they would have to do charting after a transfer and not be able to go on another transfer until their charting was completed. Mador and Shaw (2009) did review the impact of critical care information systems on time spent charting and in direct patient care by staff in the ICU, and found 12 papers that met inclusion criteria with three of them (25%) finding an increase in time spent charting, while five papers (42%) found no difference, and four papers (33%) actually reported a decrease in the time nurses spent charting. How the critical care information systems impacted direct patient care was also inconclusive.

Otieno *et. al*. (2007) looked at the nurse's views on the use, quality and user satisfaction with electronic medical records across 42 hospitals based on the responses of 1,666 nurses. They were able to build a final instrument that incorporated 34 items for evaluating electronic medical records in hospitals.

Landman *et. al.* (2012) theme of privacy/security is a concern that keeps evolving as new technologies develop and their uses in the healthcare environment are explored. Providers want to be sure when they are entering protected health

information into an ePCR at a referring facility about a pediatric patient being transported that this information is secure and encrypted. This can be especially important in a pediatric case of non-accidental trauma where the medical record will be scrutinized in a court of law. The Task Force on Medical Informatics, Section on Computers and Other Technologies, Committee on Practice and Ambulatory Medicine of the American Academy of Pediatrics released a paper in 1996, which provided practicing pediatricians with information to assist them in safeguarding the electronic storage and transmission of patient data to protect their patients and themselves (AAP Task Force 1996).

At the AAP SOTM (2012) Course on Neonatal and Pediatric Critical Care Transport Course, there was some discussion on how specialized transport teams were dealing with implementing electronic health records. Most specialized transport teams had not migrated to an electronic health record. They were still using paper charting. A small number of specialized transport teams were using commercially available ePCRs. Specialized transport teams using the ePCR seemed to be dealing with similar barriers mentioned by Landman *et. al*. (2012).

The barriers to adoption of an electronic health record are usually described in broad categories. This allows them to be applicable to many different practice types, whether inpatient, outpatient, geriatric, pediatric or transport. That does not mean each of those areas does not have their own specific barriers or

difficulties that may be unique or more accentuated for a specific area. Privacy and security may be more important and difficult to overcome in the transport environment compared to the inpatient environment because the protected health information flows through wireless internet service providers and across large geographical areas that make it more susceptible to eavesdropping.

Boonstra and Broekhuis (2010) did a systematic review of the literature and found eight categories of barriers: financial, technical, time, psychological, social, legal, organizational, and change process. Kumar and Aldrich (2010) addressed methods to overcome some barriers in the context of the physician outpatient office setting. Landman *et. al*. (2012) discussed the prehospital electronic patient care report system and some of the barriers to adoption and implementation in the prehospital setting by EMT providers, and defined themes similar to the Boonstra and Broekhuis paper (Boonstra and Broekhuis 2010): related to financial, organizational, technical, and privacy/security. Landman *et. al*. (2012) was a qualitative study using in-depth interviews from 23 participants representing 20 different EMS agencies from across the United States and Canada.

Many specialized transport teams are nurse-led (Leslie and Bose 1999), and therefore nurse attitude is a key factor influencing transition to an EHR. Laramee *et. al*. (2011) used focus groups during an EHR implementation with 40 nurses and developed four themes as being fundamental to the successful transition to

an EHR including: it will take one hundred charts; self-discovery; clear processes; and making the EHR support a customer-focused service. It will be important to include these when implementing an electronic health record in the transport environment.

Wakefield *et. al*. (2007) developed a measure of clinical information systems expectations and experiences and subsequently Ward *et al*. (2011) tested the measure on nurses' perception on how clinical information system implementation affected workflow and patient care. Unfortunately, Ward *et. al*. (2011) did not delineate nursing duties, probably because about half of the study's participants were nurses at a Midwestern rural referral hospital. Some of them most likely were transport nurses, but probably such a small number that it may not be clinically significant.

LITERATURE SEARCH:

The literature search was conducted in CINAHAL using the terms “electronic health record and neonate” and “electronic health record and neonatal transport team” and did not receive any pertinent records. The search was then widened to include such terms as “transport”, “transfer”, “retrieval”, “neonate”, and “infant” and did not get any pertinent records dealing with electronic medical or health records and neonatal or pediatric transport. The search term “electronic patient care record and neonate” did not get any pertinent records in CINAHL. EBSCO and Web of Science, PubMed searches using the terms “nursing and workflow”, “electronic health records and neonatal transport”, “electronic medical record and neonatal transport”, “electronic health records and neonatal transport team”, “electronic medical record and neonatal transport team”, returned a few articles that dealt with nursing and informatics issues, but none that had any specific information on the prevalence of neonatal transport teams utilizing electronic medical or electronic health records. Further searches were conducted using the terms “nursing and workflow” to evaluate any studies that dealt with nursing workflow in the neonatal transport team environment, which had studied implementation of an electronic health record in the neonatal transport team environment might have affected nursing workflow, but was unable to find any articles. There was one article that dealt with electronic patient care reports (ePCR) that are used by Emergency Medical Services and how these ePCR systems have been adopted by many EMS agencies for billing, quality and patient safety improvements, though they have had some challenges with implementation (Landman *et. al.* 2012), but the use of the ePCR in the

neonatal/pediatric transport environment was not discussed. There is currently no literature available dealing explicitly with barriers to implementation in the neonatal and pediatric transport team environment.

RESULTS

The many literature searches generated multiple abstracts and articles that were carefully reviewed. Table 1 below lists six of those articles that have clear discussions about barriers to implementation of an electronic medical record, but none of them discussed the neonatal/pediatric transport (NPT) environment.

TABLE 1

Author	Title	Sample	Discussed NPT environment
Boonstra et. al. 2010	Barriers to the acceptance of electronic medical records by physicians from systematic review to taxonomy and interventions	Systematic literature review on papers from 1998 to 2009 discussing barriers to the acceptance of EMRs by physicians.	No
Kumar et. al. 2010	Overcoming barriers to electronic medical record (EMR) implementation in the US healthcare system: A comparative study	Discussion paper about current US healthcare environment. No methods or results.	No
Landman et. al. 2012	Prehospital electronic patient care report systems: early experiences from Emergency Medical Services Agency	Qualitative study using in-depth interviews from members of the National Association of EMS Physicians	No

	Leaders	(NAEMSP)	
Laramee et. al. 2011	Learning from within to ensure a successful implementation of an electronic health record	Rural academic medical center using a descriptive exploratory qualitative research design using focus groups	No
McDonald 1997	The barriers to electronic medical record systems and how to overcome them	Discussion paper about barriers for acceptance of EMR	No
Yan et. al. 2013	Beyond the Focus Group: Understanding Physicians' Barriers to Electronic Medical Records	Data drawn from the Rhode Island Department of Health's mandatory 2009 Physician Health Information Technology (HIT) survey of physicians licensed and in active practice in Rhode Island or an adjacent state.	No

Most of these and other articles deal with barriers to implementation of electronic medical records in the realm of physicians (Boonstra and Broekhuis 2010, Grabenbaur, Skinner and Windle 2011,Yan, Gardner and Baier 2013) or nursing (Laramee 2011) or EMS (Landman et. al. 2012) or in general (Kumar et. al. 2010; McDonald 1997). None of these articles or any other article or abstract that

could be found dealt specifically with barriers to implementation of an electronic medical record in the neonatal pediatric transport environment.

DISCUSSION

The barriers to adoption of electronic health records in the specialized transport team environment may have close similarities between the different types of specialized transport teams depending on hospital logistics and state requirements for neonatal, pediatric and combined neonatal and pediatric teams. It is important to include all three types of specialized transport teams in this discussion because Karlsen *et. al*. (2011) showed that 42% of teams are combined neonatal and pediatric transport teams and each may have a specific need that the others do not, although it would be difficult to separate the barriers to implementation of electronic medical records from one type of specialized transport team from another.

Neonatal transport teams usually transport critically ill neonates from referring facilities, such as a newborn nursery (Level I) or a Level II special care nursery to a Level III or IV NICU. The higher the level of care the more advanced the care the patient can receive.

There are recent guidelines dealing with Levels of Neonatal Care (Barfield 2012) that reaffirm the importance of well-defined regionalization systems of perinatal care, population-based assessment of outcomes, and appropriate methods to adjust for risk. Regionalization of perinatal care is attempting to transfer expectant mothers who may deliver low birth weight infants to tertiary care centers because they have improved outcomes (Chien *et. al*. 2001).

Unfortunately, between 14% to 30% of very low birth weight infants are delivered in nontertiary hospitals (Yeast *et. al*.1998) increasing the risk for death, severe intraventricular hemorrhage, patent ductus arteriosus, respiratory distress syndrome and hospital acquired infections.

Landman *et. al*. (2012) discussed many different technical and interoperability barriers when implementing an electronic health record in a pre-hospital transport environment. These areas are paramount in the transport environment because of the many different ways data can be transmitted from these referring facilities to the accepting facilities prior to (e.g. insurance information) during (e.g. vital signs, assessments, orders), and after completion of transport (e.g. laboratory test results that need to be transmitted to the accepting facility). O'Reilly and Schmolzer (2012) mention many of the monitoring aspects that are specific to the neonatal population and the importance of what some of the monitoring waveforms mean and how they change under different clinical scenarios. Many monitors allow transmission of data to an electronic health record. Neonatal Transport Teams also have some very specialized equipment, such as whole body cooling, and some neonatal transport teams are now doing active cooling during transport for infants who have hypoxic-ischemic encephalopathy (Hobson *et. al.* 2011 and Johnston *et. al.* 2012). This equipment records core temperatures and surface temperatures frequently. The set point temperature is entered per protocol to keep the patient's core body temperature within a narrow range to reduce swelling of the brain. The equipment is used to prevent wide

fluctuations in temperature, which increases mortality when elevated temperatures are recorded (Laptook *et. al.* 2007) and that data is commonly used for continuous quality improvement. No current electronic health record has any module for recording these many data points and expressing it in visual graph form, or the ability to upload the data to data registry, such as the Florida Neonatal Neurological Network (FN3 2013), which is currently collecting all the cooling patient data for the state of Florida in a state registry.

Other specialized equipment includes high frequency ventilators that are not commonly used in adults (Honey *et. al.* 2007 and Mainali *et. al.* 2007). These ventilators allow the transport of very critical patients that would most likely have died at the referring facility or would not have been allowed to be transported for life-saving therapies and many ePCRs will not allow users to enter a rate of 420 breaths per minute, which is standard in High Frequency Jet Ventilators (HFJV) or express respiratory rate in hertz, mean airway pressure and amplitude, which is standard in High Frequency Oscillator Ventilators (HFOV). Inhaled nitric oxide (iNO) is another specialized therapy that can be started by specialized transport teams, but not EMS teams and needs to be recorded precisely when it is started and at how many parts per million. Extracorporeal membrane oxygenation is the most specialized therapy (ECMO) and is only done by a very few specialized neonatal or pediatric transport teams and requires a large amount of equipment (1670 lbs) and expertise to be able to transport a neonate or pediatric patient on ECMO by ground or fixed wing many miles—6700 miles was longest transport

(Wilson *et. al.* 2002). It was described by Cornish *et. al*. (1986) as an inflight use of ECMO because at that time there were only two ECMO centers west of the Mississippi in the United States and most of the ECMO patients had to be transported to receive appropriate care (Cornish *et. al*. 1991). ECMO requires a great deal of attention to detail with many values to be recorded and followed, such as mixed venous saturation of oxyhemoglobin ($\%S_{VO2}$), FIO_2, respiratory rate, PIP, PEEP, mixed PaO_2, systolic blood pressure, diastolic blood pressures, circuit flow, arterial blood gases, activated clotting time (usually measured hourly), hematocrit, platelet count, fibrinogen levels, etc. (Gattinoni *et. al*. 2011). It would be highly unlikely that a commercial ePCR has built a module for ECMO pediatric transport, but such a module would be invaluable in providing care for patients on ECMO.

Another aspect under the technical theme (Landman *et. al*. 2012) for the neonatal transport team is the actual stress on the machines, stress of trying to enter data into the ePCR while transporting and how the stress of transport affects the patient and the healthcare provider. There are physical stressors (Bouchut *et. al.* 2011) during helicopter flights on neonates and noise levels that can be quite high during fixed winged flights (Sittig *et. al.* 2011) that have significant impact on how well the transport is tolerated by the neonate. Buckland (2003) showed sound peaks of up to 121 dB in helicopter flights and that flying in either fixed wing or by helicopter had higher levels of sounds compared to ambulance. Also, the stress of flight can have effects on the

transport crew (Carchietti *et. al*. 2011). Neonatal transport teams are also called upon to provide transport during evacuation due to natural disasters and simulations for preparedness (Femino *et. al.* 2013).

It is during these high stress situations that dealing with a poorly designed or implemented ePCR may lead to “workarounds” or waiting to the end of the transport to enter data into the ePCR. Debono *et. al*. (2013) paper said that workaround behaviors can occur to compensate for inadequate technology and can enable, yet potentially compromise patient care and safety.

Pediatric transport teams are different than neonatal transport teams and will have different needs in an ePCR and may have different barriers of adoption of an ePCR that are unique to pediatric transport teams duties. Pediatric transport teams usually transport any infant or child less than eighteen years of age, no trauma calls or scene calls (scene of motor vehicle crashes). This greatly depends on hospital, regional and state logistics as in the case of Intermountain Life Flight, which does traumatic injuries and injured children < 5 years of age (Holleran and Linsler 2006). Holleran and Linsler (2006) also list the indication for transfer and transport of pediatric patients that can be a great help to outside facilities. This implies that many features in an ePCR that the pediatric transport team needs may be there because many EMS providers also transport pediatric patients.

The ePCR has to be mobile. These pediatric transport teams typically transport pediatric patients from referring facilities' Emergency Rooms, Pediatric Floor, Pediatric Acute Care or Pediatric Intensive Care Units to other tertiary care or quaternary care facilities for critical care or specialized care that is not available at the referring facility. Pediatric specialized transport teams are associated with improved outcomes (Orr *et. al.* 2009) compared to typical EMS providers. We have already discussed that Orr *et. al*. (2009) showed > 2 fold increase in mortality when pediatric patients were transported by EMS providers compared to their specialized pediatric team.

Spooner (2007) lists many critical electronic health record functional areas, such as immunization management, growth tracking, medication dosing, patient identification, norms for pediatric data and privacy. Kim *et. al*. (2008) cover many of the inpatient pediatric aspects that are needed in electronic health records to be utilized inside the children's hospital. Kim *et. al*. (2008) also mention transport services as an inpatient transaction, but does not go into any detail. The paper does discuss handoffs or sign-outs in detail.

Neonatal and Pediatric Transport Teams do a combination of both patient populations (neonates, infants, and pediatric) and have a wide expertise level with strong constraints for competencies in many different areas. They have to be able to do neonatal procedures such as intubations, umbilical arterial catheter, umbilical venous catheter, peripheral intravenous catheter, thoracotomy, needle

decompression (Holleran and Linsler 2006), and deal with neonatal surgical emergencies (Lockridge, Caldwell and Jason 2002) such as omphalocele, gastroschisis, congenital diaphragmatic hernia, and hypoxic ischemic encephalopathy with either whole body cooling or head cooling. They also have to be able to do other procedures for the pediatric population such as intraosseous access, peripheral intravenous access, continuous nebulizer medication administration, needle thoracentesis, thoracotomy, intubations, etc., (Holleran and Linsler 2006). There is a great amount of procedural work that may occur with one transport that has to be documented when the procedure occurs, during the transport, and when the patient is transferred over. This may be a barrier to adoption of ePCR because similar to Landman et. al. (2012) where "the increased amount of time that's required to fill out an electronic patient care report has a huge impact on their ability to provide care to their patients".

Many of these specialized teams: neonatal, neonatal/pediatric or pediatric transport teams work under the auspice of a children's hospital or a consortium of hospitals and EMS providers. This has to do with many factors and logistics. Many hospitals cannot afford to keep all the transport personnel and equipment that is needed, which goes along with Landman *et. al*. (2012) theme of financial. Specialized transport teams usually are not big money makers for hospitals and most of the time they actually lose money on the transports in the short run

because reimbursement of the transport is “bundle charged” for many instances and/or reimbursement by Medicaid is poor.

These specialized transport teams also help develop brand presence that allows the children’s hospital to gain referrals for specialized procedures that do bring in revenue to the hospital. When these specialized transport teams go out and pick up referrals from Emergency Departments, Community Hospitals and other areas and facilities, they come in contact with and sometimes are a part of other Emergency Medical Services for specific regions.

Most specialized teams have an EMT that is trained to drive the ambulance and sometimes assist with the transports. Then there is usually both a Registered Nurse (RN) and a Registered Therapist (RT), who make up the team or a RN/RN team. There are many configurations of team composition, but the most common is RN/RT (Karlsen *et. al.* 2011). Many EMS transports are run by an EMT-Basic (EMT-B) with another EMT-B for basic life support (BLS) or a team of EMT-B and EMT-Paramedic (EMT-P) for advanced life support (ALS). Many of these providers are volunteer and do not get much pediatric experience and the skills they do have can deteriorate quickly without practice (IOM 2007). This can lead to difficult situations (Sanders, Fringer and Swor 2012) where EMS providers are called to provide prehospital care for infants born at the edge of viability and evaluated an infant as non-viable, subsequently the infant is transported to the ED where the infant is determined to be resuscitable.

The specialized transport teams have to find RNs and RTs who understand that there is a paucity of specialized equipment, personnel and clinical specialists in the prehospital setting. At times, these transport teams are seen as "the cavalry" and while the transport team would like the patient to be optimally stable prior to transport, the transferring facility is often focused on expediting the transport as quickly as possible (Borrows *et. al.* 2010). Stabilization time is a critical time period where the specialized transport team arrives at the referring facility to prepare the patient for transport. It is during this time that the specialized transport team attempts to restore physiologic stability prior to moving the patient (Borrows *et. al.* 2010). If the neonate, infant or child's physiologic stability is not improved or returned to as normal as possible prior to transport, those transports are associated with serious adverse events and the need for emergency interventions while en-route (Macnab 1991). This can be juxtaposed to how most adult EMS teams are run with the "swoop and scoop" or "scoop and run" mentality. These are different patient populations and different constraints and the same system cannot be used for different populations, due to the risk of worsening the outcomes of the pediatric patients (Stroud 2008). This is one aspect of specialized transport teams that ePCR adoption might be made easier. According to Landman *et. al*. (2012) theme of organizational ePCR could be seen as a positive effect to the healthcare providers based on the transport team's ability to enter the patient's need for specialized equipment (e.g. HFJV, iNO), personnel (e.g. pediatric cardiologist) and clinical specialist (e.g. echocardiogram technician at bedside on admission) to the accepting facility.

The transport team could enter current respiratory settings, vasoactive drips, medications, nursing orders, into the ePCR, as a plan of care and the accepting facility receives them wirelessly prior to the patient. The accepting facility can then have the equipment ready and the plan of care in place on arrival.

These specialized teams can also be called upon to provide comfort care to a neonate or infant and their family when the child has no hope of survival and the specialized team is tasked with providing compassionate care to an infant and their family (Buchanan 2009). They may also have to bring infants or pediatric patients from the hospital to hospice or home and provide compassionate extubation bridging the intensive and palliative care environment in a continuum of care (Zwerdling, Hamann and Kon 2006). There also is precedence in place where the specialized transport teams go to the referring facility prior to the delivery of a high-risk neonate to help with stabilization of the neonate to help improve outcomes (McNamara, Mak, and Whyte 2005). All of those special situations have to be dealt with because the ePCR will need to be able to generate orders and document care.

Landman *et. al*. (2012) emphasized the importance of leveraging existing regional health information organizations (RHIO) to help overcome the technical barrier. A key challenge is coordination, one of the most common and long-standing problems faced by EMS providers. EMS, hospitals, trauma centers, public health, and specialized transport teams have worked in silos. Also,

emergency care providers lack the ability to access patient's medical history/medications and pertinent information that could be useful in making medical decisions. Only about half of hospitals have pediatric interfacility transfer agreements that help improve communications between hospitals (IOM 2007).

The literature examining Emergency Medical Services (EMS), which is also a pre-hospital service usually provided by Emergency Medical Technicians (EMT) and/or Paramedics (EMT-P) does not, in general, address any facet of health information technology and how it interfaces or communicates with other healthcare providers, although a paper by Foltin *et. al*. (2010) lists 15 clinical topics: airway management, respiratory distress, trauma, asthma, head trauma, shock, pain, seizures, respiratory arrest, c-spine immobilization, cardiac arrest, injury prevention, children with special needs, poisoning, abuse and neglect. It also lists five system topics: effectiveness of out-of-hospital interventions, knowledge and skill deterioration, patient outcomes, evaluation of the impact of overall EMS system changes on children, and training effectiveness (Foltin *et. al.* 2010). It is unfortunate that more emphasis was not placed on health information technology and how HIT could be used to improve care and outcomes of patients.

Many Emergency Medical Services (EMS) have gone to their own type of electronic medical record, which is called an Electronic Patient Care Report (ePCR) and sometimes an Electronic Pre-Hospital Patient Report based on what

they called their paper based records prior to electronic medical records. The ePCR is similar to an electronic medical record (EMR), but has documentation streamlined for the pre-hospital situations and other aspects that are not readily found in commercial EMRs. There are many of those systems in place throughout the United States being used by rural and urban emergency medical technicians and paramedics (EMSWORLD 2012 and EMS1 2013).

Because many specialized teams, such as neonatal/pediatric transport teams are associated with hospital EMS providers or EMS providers are driving the ambulance for the neonatal/pediatric team, they have gone to using an ePCR for their documentation needs. Some commercial ePCRs do cater to specialized transport teams, for example an ePCR (ImageTrend's EMS Field Bridge™[ImageTrend, Inc., Lakeville, MN]) that has an expansion module for Critical Care Services that allows for the collection of over 200 additional data points related to critical care including air-related, neonatal and high risk OB (ImageTrend 2013). Also, emsCharts (emsCharts, Pittsburg, PA) has enhanced their pediatric and neonatal care functionality (emsCharts 2013). It is not known if these upgrades or enhancements are used by any of the specialized neonatal/pediatric transport teams or if they meet the needs of those teams.

Additionally, it is not known if all the data elements discussed by Riordan and Porcelli Jr. (2009): maternal age, maternal past medical history, maternal prior pregnancies, maternal prior neonatal illnesses, maternal history of current

pregnancy, gestational age, number of expected fetuses, prenatal studies, pregnancy complications, fetal ultrasound, fetal echocardiogram, maternal infections during pregnancy, pregnancy interventions, labor & delivery, etc., (See Appendix I for complete list) have been covered by many ePCR vendors.

Furthermore, these ePCR may not have many of the data elements needed for specialized pediatric critical care transports and those needed that provide extracorporeal membrane oxygenation (ECMO) on transport or take care of pediatric burns patients. Spooner (2007) lists many of the special requirements of an Electronic Medical Record system applicable for pediatric patients and describes many of the problems associated when an adult EHR in the outpatient setting is used for a pediatric population. The paper, unfortunately, does not cover prehospital transfers or transports. Kim *et.al.* (2008) cover many of the requirements needed for pediatric inpatient settings and does discuss transfer from one unit to another inside a hospital (from the floor to the PICU as an example), but does not mention interfacility transports. These systems can be costly. Teufel II *et. al.* (2012) showed a 7% additional cost per case, when transitioning from paper to an EHR for inpatient pediatrics.

There have been numerous reported challenges described for healthcare information technology adoption in primary care and hospital care settings (Boonstra and Broekhuis 2010). Furthermore, Sittig and Singh (2010) discuss the legal, ethical, and financial difficulties associated with electronic health record

adoption. This research has focused primarily on physicians' barriers to electronic medical records (Yan, Gardner, and Baier 2012) with some on nursing barriers (Laramee *et. al.* 2011).

There has been only one paper that looked at implementation of electronic medical records in the pre-hospital setting (Landman *et. al.* 2012), but it focused on Emergency Medical Services and did not address neonatal/pediatric transport. However, the themes developed by Landman *et. al.* (2012) can be applied to the neonatal and pediatric transport setting with little distortion and can be used as a basis to assist with implementation of an electronic health record in the pre-hospital transport setting. In the United States, most neonatal/pediatric transport teams are nurse led (Karlsen *et. al.* 2011), which means that the nurse is on the transport, assessing the patient, making decisions, discussing the case with the medical control physician back at the accepting facility, as well as speaking with the nurses and physician at the referring facility. This may put a different layer of complexity to the logistics of adoption of an electronic health record.

The first theme from Landman *et. al*. (2012) is financial. The respondents listed the high start-up costs and the lack of funding for state mandated ePCR system implementation as a significant barrier, but many were able to identify alternative, creative funding sources. One EMS agency had their ePCR purchase

subsidized by their billing company because it reduced the number of claims that were denied and increased revenue.

The IOM report Emergency Care for Children (2007) lists some ways to overcome this barrier. They recommend federal agencies and private industry fund research on pediatric-specific technology and equipment for use by emergency and trauma care personnel (IOM 2007). Furthermore, they emphasize that while many hospitals, EMS systems, and government entities are investing in information technologies, the safety, impact and risk of these systems on pediatric patients have not been studied. They also discussed that EHR must be designed so that healthcare providers can record weights and measurements with a specificity appropriate for newborns and infants (big difference between a 500 gram infant and a 1250 gram infant) and CPOE tools must be designed with pediatric specific weight-based dosing charts (IOM 2007).

The next theme from Landman *et. al.* (2012) is organizational. This can be very daunting because many EMS providers and specialized neonatal and pediatric transport teams have complex and often confusing organizational charts. Neonatal and pediatric transport teams can be responsible for many different departments and organizations as some transport services are more of a partnership to try and reduce cost and overhead. This can make leadership difficult because the medical leader may not be the responsible cost center for

the specialized transport team. Thus at times even strong leadership, as suggested by Landman *et. al*. (2012) may not be successful in pushing the agenda forward toward successful ePCR implementation. In this situation, a creative solution may be best. Many organizations will have certain mandates, and if EHR implementation for the neonatal and pediatric transport team can be linked to a priority mandate—say patient safety, then, the likelihood of obtaining funding is higher, and more importantly, the organizational fortitude (CEO involvement) to accomplish this project.

Appropriate backing of the organization is critical. One system that is mentioned frequently is VistA the Veterans Health Information Systems and Technology Architecture (VistA). It is the EHR for the Veterans Health Administration and it has been a successful implementation of an EHR and the majority of the success is due to the organizations desire to continue working on it until they get it right (Grabenbauer, Skinner and Windle 2011).

The next theme according to Landman *et. al.* (2012) is technical. The respondents from Landman *et. al*. (2012) remarked about the poor user interface design and unreliable vendors. Three respondents out of a total of twenty said they overcame this barrier by working with their existing community RHIO to electronically exchange ePCR. RHIOs are usually a non-profit entity that facilitates health information exchange among healthcare providers in a defined

area. These three respondents were able to use existing established infrastructure, and make a single electronic interface with the RHIO and exchange information with all participating hospitals and physician offices (Landman et. al. 2012).

Hinman and Davidson (2009) showed that in Colorado, the technology was not the limiting factor. They developed Colorado's RHIO and showed that linkage of Colorado-based information has occurred in a number of ways with Public Health Information Systems, Emergency Medical Services (focused primarily on trauma registries and motor vehicle crash databases), and School Health Information Systems. Injury data are currently linked between the law enforcement motor vehicle crash reports, the EMS prehospital system, inpatient care, and the trauma registry. This data is used to try and find areas of increased rates of motor vehicle crashes (Hinman and Davidson 2009). They concluded that technology to link information systems together exists today; involvement of all stakeholders is essential to define the requirements of the linked systems; standards are a must for implementation of linked system requirements; national coordination of efforts should proceed through a public-private collaboration, rather than through a governmental body; and lastly development of a RHIO/HIE is a multi-year undertaking and is expensive (Hinman and Davidson 2009).

There are areas throughout the country that have had HIEs (McDonald *et. al.* 1997) where information is readily available and where EMS already has ability to look up patient data prior to arriving at a call for a patient who was unable to communicate their health history, unconscious, uncooperative, intoxicated or elderly (Finnell and Overhage 2010). The Indiana Network for Patient Care (INPC)—an operational statewide health information exchange (HIE) was linked to a county EMS providers ePCR with a large button that the EMT-P could push to access prior medical history on the patient in question (Finnell and Overhage 2010).

An example of a linked information system is Finnell, Overhage and Grannis (2011) where these authors described the patient crossover rates throughout the entire State of Indiana over a three-year period. They looked at 96 different Emergency Departments with a total of 7.4 million visits. These authors were able to show more than 40% of ED visits during the three-year period were from patients having visited multiple institutions (Finnell, Overhage, and Grannis 2011).

There is also a recent report that looked at one hospital using a cloud based service that started with the Orthopedic department, but has progressed to where any referring provider can upload a wide range of medical image studies that can be downloaded when the patient arrives to Boston Children's Hospital (Rosebach

2012). This allows the accepting physicians to be able to see medical imaging prior to the child arriving and being able to write orders, prepare and plan accordingly before the child even arrives. This reduces cost by not having to repeat expensive imaging tests and can be life-saving in some instances.

Another technical concern is how to train the specialized transport team personnel to use the electronic medical records. It might be wise to use simulated patients in the transport environment until the workflow dynamics and nursing/respiratory workflow is figured out (March *et. al.* 2013) because of the increased risk for error and patient safety risk. Simulation is commonly used for specialized transport team personnel and most are used to using simulation for competency and training (Cross and Wilson 2009). Scenarios are commonly developed for specialized transport personnel where there are equipment malfunctions or unusual patient scenarios, such as omphaloceles of meconium aspiration syndrome. When the same scenarios are enacted using the electronic health record for charting purposes and recording the changes to workflow, then interdisciplinary teams functioning can be assessed and fostered. Additionally, simulation allows assessment of competency with respect to identifying and acting on information errors.

The last theme from Landman *et. al.* (2012) is Privacy/Security. Landman *et.al*. (2012) respondents mention concerns about privacy and security related to transfer of information—how to transfer information in a secure way that doesn't violate HIPAA or make the hospitals information system crash. Peng *et. al*. (2009) using an SRM Platform was able to assure that sensitive information could be transmitted electronically. The SRM Platform was based on enterprise standards for secure and reliable transmission of private or sensitive messages and data over the Internet and was designed for organizational information exchange needs such as government, healthcare providers, hospitals, pharmacies, and HIEs (Peng et. al. 2009). The paper was a proof of concept testing in an informatics lab at the CDC using standard HL7 files and a 140MB zipped binary file. The SRM Platform implemented the high security and reliability standards by using standards: WS-Security, WS-Reliable Messaging, WS-Security Policy, WS-Trust and WS-Interoperability (Peng *et. al.* 2009).

CONCLUSIONS

There are many facets and areas that have to come together before many specialized transport teams will be able to adopt electronic health records and use them well. We can think of these areas based on different perspectives either an international, national, state, regional and community level and individual agency and how the specialized transport teams interact at each level. Landman et. al. (2012) developed themes for the EMS community, but was also applicable to the specialized transport team environment and covers most of the perceived barriers.

Most of these barriers can be overcome with creative funding, technical expertise, enhancing internal IT capacity and strong leadership. The Landman *et. al*. (2012) theme of organizational is the biggest barrier/struggle facing specialized transport teams. These specialized transport teams need to be better recognized for the skills and expertise they bring on transport to the healthcare and EMS communities.

Another viewpoint would be by service orientation, neonatal intensive care unit, pediatric emergency department, pediatric intensive care unit, emergency medical service, volunteer fire department, etc., to make sure barriers that are more specific to the NICU or PICU are covered. This has more to do with the Landman et. al. (2012) theme technical because it is more about having the data

standards for correct input of data, as well as data standards for data exchange, and interoperability (Hinman and Davidson 2009). There is going to have to be a large investment in collaboration, communication, regionalization, and accountability with all stateholders involved to make this happen.

We are going to have to change the service orientation from a primarily voice communication, where currently the specialized transport personnel calls the referring facility—speaks with the bedside nurse to get a report, to 50/50 voice and data communication to allow medical records, labs, radiology and other data to be transmitted electronically from one facility to another or to be carried by the specialized transport team personnel and uploaded at the children's hospital (IOM 2007).

Implementing an electronic health record in the neonatal and pediatric transport environment will be an arduous undertaking, but one that is needed to improve quality of care, reduce medication errors and improve patient safety. The barriers are real: financial, organizational, technical and privacy/security, but these barriers can be overcome with the right amount of organizational fortitude and willpower.

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APPENDIX

Neonatal Care and Data (O'Riordan and Porcelli 2009)

Data Elements:

Maternal:

- Maternal Age
- Maternal Past Medical History
- Prior Pregnancies and Neonatal Illnesses
- Family History
- History of Current Pregnancy
  - Gestational Age
  - Number of Expected Fetuses
  - Prenatal Studies
  - Pregnancy Complications
  - Fetal Ultrasounds/Echocardiograms
  - Maternal Infections During Pregnancy
  - Pregnancy Interventions
  - Consulting Physicians
- Labor and Delivery

Infant

- Neonatal Resuscitation
- Ambiguous Genitalia

Specific Issues for Neonatal Information Systems

Handling Infant Name Changes

Improving NICU Medication Delivery

Neonatal Drug Dosing

Delivering Drugs in Emergencies: The Code Card