NEONATOLOGY TODAY

News and Information for BC/BE Neonatologists and Perinatologists

Volume 10 / Issue 1
January 2015

IN THIS ISSUE

NEONATOLOGY TODAY

ISSN: 1932-7129 (print); 1932-7137 (online).

Company Offices:
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China California Heart Watch Yunnan Province Pediatric Heart Training Program

By Tao Guo MD; Jia Hua Pan, MD; Fangqi Guo, MS; Shan Shan Chen; Song Yuan Tang, PhD; Yang Juan Bai, RN; Cheng Loh, MD; Robert Detrano, MD, PhD

Summary

Undiagnosed congenital cardiac shunt lesions with Pulmonary Hypertension and Critical Duct-Dependent Congenital Heart Disease kill 3 to 4 of every thousand children born in developing countries. Most of these heart defects are curable if discovered early. We are conducting a training program for doctors responsible for the care of neonates and small infants in rural Yunnan Province, China. We are teaching the doctors proper cardiac examination of neonates and small infants. Though rural Yunnan is one of the poorest regions of China, both medical insurance options and financial assistance mechanisms are growing, and the level of medical care is continuously improving. The conditions for increased awareness and discovery of undiagnosed congenital heart cases are, therefore, ideal for addressing this problem in Yunnan Province. We plan to train all county hospital and most town hospital doctors who are responsible for the care of newborns and small infants to do proper cardiac examinations including pulse oximetry in the newborn, and stethoscope examination in newborns and infants less than one year of age. The present application addresses the problem of objective evaluation of our training project using the Kirkpatrick four-step model.

"We are conducting a training program for doctors responsible for the care of neonates and small infants in rural Yunnan Province, China."

Project Aims

The aims of this project are to:

- Improve knowledge regarding the significance and detection of large shunt lesions and Critical Congenital Heart Disease (CCHD) in the newborn.
- Beneficially change behavior on the part of the trainee physicians and nurses.
- Increase case findings compared to a period immediately prior to the execution of the program.

Introduction

Mission of the China California Heart Watch

The mission of our organization is to teach, research and provide clinical care regarding Cardiovascular Disease in rural Yunnan Province. Our major focus has turned toward pediatric congenital heart disease prevention, detection and treatment. During the past five years, we have screened over 90,000 school children for Congenital Heart Disease (CHD), and discovered approximately 500 cases. Of these, about 200 were amenable to interventional or surgical correction, and all have undergone or will soon undergo correction. Unfor-

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tunately, we have discovered approximately 50 cases (10%) with large shunt lesions and pulmonary hypertension, for whom surgical correction cannot be done because diagnoses were not made sufficiently early for effective life-saving treatment.

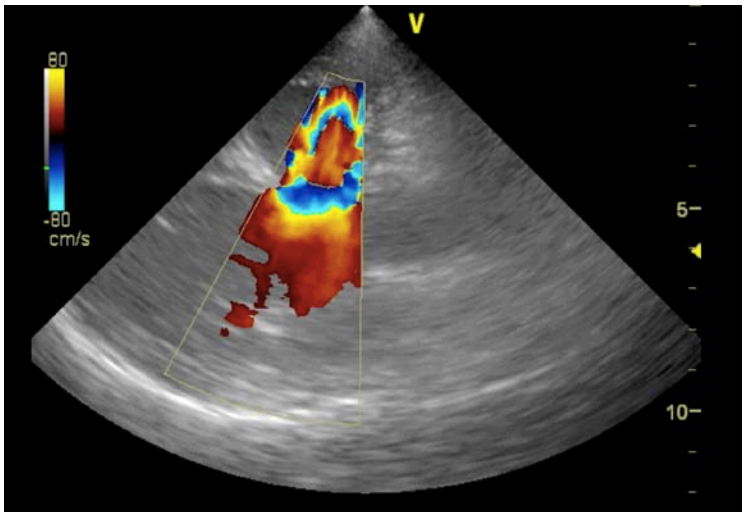
The Problems

Despite rapid advances in the level of rural Chinese pediatric cardiac care, two distinct problems remain to be solved.

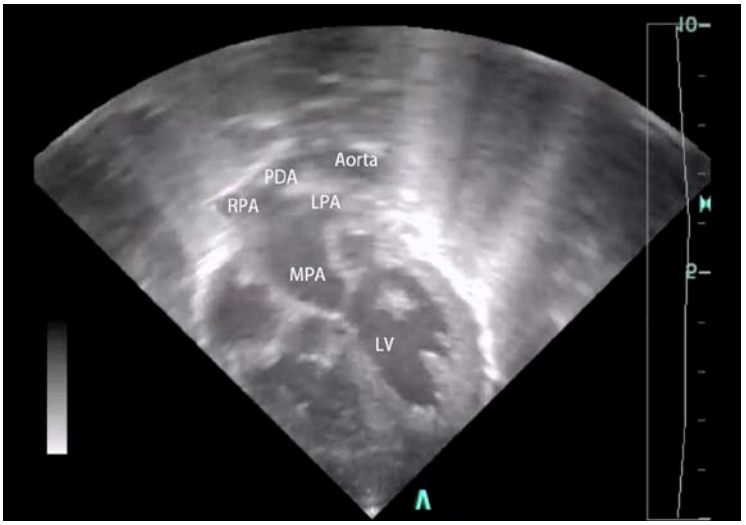
- **Early Diagnosis of Shunt Lesions with Pulmonary Hypertension:** Failure to make sufficiently early diagnosis of significant shunt lesions that lead to pulmonary hypertension and deterioration of pulmonary vasculature.
- **Failure to Recognize and Treat the Critical Duct-Dependent Disease in the Newborn.**

1. Early Diagnosis of Shunt Lesions with Pulmonary Hypertension. Congenital Heart Diseases are the most common congenital anomalies, and a leading cause of death in newborns and young children.[1] A high percentage of CHD lesions involve moderately restrictive or non-restrictive ventricular septal defects, Patent Ductus Arteriosus and double outlet right ventricles, which result in gradual deterioration of the pulmonary arterial walls leading eventually to irreversible pulmonary vasculature disease and Eisenmenger's Syndrome.[2,3]

During five years of work in rural Yunnan Province, we have found that medical personnel are not sufficiently trained to detect CHD in newborns. The result is that children with large ventricular septal or other defects go undetected and exhibit first symptoms between 5 and 15 years of age, when pulmonary artery pressure approaches systemic levels and symptoms of right-to-left shunting develop.[4] By this time, catheterization shows increased, irreversible pulmonary vascular resistance, indicating that it is too late for corrective surgery. These patients



Large peri-membranous ventricular septal defect with bi-directional shunting of blood in a cyanotic 14-year-old girl with high hematocrit and high pulmonary vascular resistance that was not reversible on 100% oxygen.



21-day-old male infant with Transposition of the Great Vessels. Baby underwent successful arterial switch operation.

Trainee doctor contemplates infant with abnormal pulse oximetry reading.

die in young adulthood. Newborn and infant screening can prevent this tragic scenario. Screening would require adequate examination with a standard stethoscope and pulse oximetry at birth, followed by a thorough stethoscope examination at one to six months of age. Our purpose is to develop a method for local doctors to make educated decisions regarding further examination. This method can be applied in other developing countries, which do not have sufficiently trained local personnel to accurately diagnose infantile CHD.

2. Critical Duct-Dependent Disease of the Newborn. About one to two per 1000 newborn babies have CCHD, which is defined as disease that causes death or needs invasive intervention in the neonatal period. Neonates with this disease benefit most from early detection.[5] During the past few years, several studies have supported the addition of pulse

Professor Jia Hua Pan lectures rural doctors on the importance of detecting large cardiac shunt lesions and Critical Congenital Heart Disease in newborns.

oximetry to routine clinical assessment as a complementary method for detection of CCHD.[6–11] It is important to note that one of the largest and perhaps the best evaluation of this technology was done in China.[2] These investigators screened 6,785 consecutive newborn babies using pulse oximetry and clinical assessment at birth. They found that pulse oximetry plus clinical assessment is feasible and reliable for the detection of major congenital heart disease in newborn babies in China. They recommended that this simple and accurate combined method should be used in maternity hospitals throughout China to screen for CHD.

Preliminary Work

We executed a pilot program in Hong He Prefecture, Yunnan Province, to train local physicians, who attend at births, on the proper use of a common stethoscope for screening neonates. We chose Hong He because 80% of all babies there are born in county hospitals, which is a trend in rural Yunnan.

During this preliminary pilot program in Hong He Prefecture, we first assessed 73 county obstetricians who attend at births in their cardiac examination of neonates using a checklist completed by a cardiac nurse at the bedside. The results of this assessment are in Table 1. Note that most of the county doctors attempted some kind of cardiac examination, though only 20 of the 73 performed a four-point cardiac exam and measured heart rate. None of the hospitals had pulse oximetry available.

Table 1. Pre Training Cardiac Exams in Hong He Prefecture

No Cardiac	1 auscul	2 auscul	3 auscul	4 auscul	Heart Rate	Blood Pressure	Pulse Ox
exam	point	points	points	points			
2	25	20	6	20	36	0	0

At the end of the assessment we trained the doctors to:

- Proper use of a standard stethoscope;
- Do complete physical examination on all neonates.
- Refer all babies with suspected heart murmurs for echocardiograph.

The Hong He prefecture health department supported this work. This preliminary evaluation proves the feasibility of this type of training.

Knowledge Assessment Before and After Training

A second preliminary training trip was made to De Hong Prefecture in the southwest corner of Yunnan Province. Four Kunming doctors travelled to Dehong for a period of one week. One hundred ninety-five local doctors were assembled in three locations. Both practical training and didactic lectures were given in each place. Student doctors were tested before and after didactic lecture, using 38 questions (multiple choice and true/false). Questions covered topics ranging from proper stethoscope placement to proper presentation of abnormal results to families.

Scores before and after listening to lectures are presented in Table 2.

Table 2. Before and After Training Scores on 38 Question Exam Administered to Trainees in De Hong Prefecture

	N	Lowest Score	Highest Score	Mean Score	SD Score	Passed Exam	T	P
Before	195	6	38	21.8	6.54484	33.7%	-11.311	<0.001
After	169	14	45	29.8	6.83372	66.3%		

Work Plan

We have established a training school centered in Yunnan Province capital Kunming city with a five-person Directors' Committee consisting of a School Director, a public health expert, a cardiologist, a nurse, and an administrator. We have trained rural doctors in two prefectures, and in the coming months plan to train in a third prefecture.

This committee has the following responsibilities:

1. Arrange with the Yunnan Department of Health and the prefecture departments of health for the training sessions and supervision of rural doctors regarding the proper cardiac examination of newborns and infants, including stethoscope exam, heart rate measurement and pulse oximetry in neonates and stethoscope examination in both neonates and infants at 3 to 6 months of age.
2. Train 6 to 12 Kunming cardiologists and pediatricians regarding who will, in turn, train local rural doctors responsible for the care of neonates and infants how to properly examine their patients at birth and again before the sixth month of life.
3. Assess effectiveness of training with repeat visits to county and town hospitals to assess case findings assuming that incidence of CHD is at least 4 per thousand.

Learning Objectives

The objectives of this training program are:

1. Trainees (physicians responsible for care of newborns and young infants) should understand the pathophysiology of large cardiac shunt lesions and pulmonary hypertension.
2. Trainees should understand the pathophysiology of Critical Duct-Dependent Congenital Heart Disease.
3. Trainees should have simple stethoscopes.
4. Trainees should be able to distinguish neonates and infants with and without heart murmurs.
5. Trainees, working in county hospitals, should have access to high quality pulse-oximetry, available near or in delivery rooms and neonatal ward units.
6. Trainees working in county hospitals should demonstrate proficiency in the use of high quality pulse-oximeters.
7. Trainees working in county hospitals should recommend immediate echocardiography examination within 24 hours before discharge for neonates / young infants who have failed the pulse oximetry and clinical examination screening.
8. Trainees working in county hospitals should be able to explain to parents the purpose of screening, the meaning of a pass / fail result, and provide parents information regarding referral centers in Kunming.

Evaluation and Assessment

Evaluation of the training program will utilize the Donald Kirkpatrick Four Step Evaluation Model.[13,14] The four steps of evaluation consist of:

- **Step 1: Reaction** - How well did the learners like the learning process?
- **Step 2: Learning** - What did they learn?
- **Step 3: Behavior Modification** - What changes in job performance resulted from the learning process?
- **Step 4: Results** - What are the tangible results of the learning process in terms of case findings and treatments?

Step 1. Reaction

Immediately after each training session, a questionnaire will be administered to all trainees.

The questionnaire will consist of the following questions:

- Was the training worth your time?
- Was the training successful?
- What were the greatest strengths of the training and the greatest weaknesses?
- Did you like the presentation style?

Step 2. Learning

Learning will be assessed using structured quizzes administered at the end of each training session and with assessment of behavior modification by a graduate student led team of research personnel between three and six months following the training sessions.

Quizzes are administered before and after the training and will cover the following subjects:

1. Pathophysiology and clinical prognosis of untreated shunt lesions with pulmonary hypertension.
2. Potential treatment options for patients with untreated shunt lesions with pulmonary hypertension.
3. Pathophysiology and clinical prognosis of untreated critical duct dependent lesions.
4. Potential treatment options for patients with untreated critical duct-dependent lesions.
5. Assessment of proficiency in distinguishing normal from abnormal heart sounds.
6. Assessment of proficiency in the performance of pulse oximetry examinations.
7. Proficiency in explaining to families the reasons for screening.
8. Proficiency in explaining to families the nature of CHD and the possibility of treatment.

Step 3. Behavior Modification

Behavior modification will be assessed by a team consisting of a graduate student and a team of research personnel on the county hospital level.

The team will use a checklist method to assess the behavior of the trainees before and three-to-six months after the training.

The Masimo Corporation of Irvine, California, has donated 125 Rad-5 SET pulse oximeters to this research. These devices are being distributed to each of the 125 rural county hospitals in Yunnan Province. We will be using a protocol similar to that of Granelli et al and Zhao et al to assess foot and hand blood oxygen saturation.[12,16]

These devices have an internal memory that retains the pulse oximetry results. Local county hospital personnel will be given instruction in the use of these devices, and how to download measurement results to a local computer and send these results to personnel at Kunming Medical University and to the University of California, Irvine. The graduate students will analyze completeness of measurement by comparing the number of properly recorded pulse oximetry results with the number of newborns at the respective hospitals.

Step 4. Results

Concrete results of the training will be newly discovered cases of CHD, shunt lesions and CCHD.

Additional results of the training will be the increase in provincial rural children undergoing surgery for CHD as assessed by the Yunnan Department of Health.

Statistics on the known cases of CHD and the number of surgeries will be obtained from the local county health department records in the year 2013 before training began. These will be compared with the cases found in 2016 after the completion of training.

Power Calculation for Case Finding

If the 2013 incidence of heart disease is 5 cases per thousand live births and if there are 200,000 live births in a province, and we require that our training program increases case finding by 2% to an incidence of 7%, our training program would have a power of 99% to find a 2% increase.

If we evaluate only 10,000 of the babies born in counties where we train, then the power to find a 2% increase in incidence would 77%.

Here we are using the one-sample binomial test with the typical normal approximation.[16]

Conclusion

As treatment facilities increase in number in developing areas of China and the world, such a training model will become more relevant. Our program can thus serve as a model for other underdeveloped areas in China and other developing nations. The China Cal Board of Directors contains members who are consultants to the Chinese Ministry of Health. They will ensure that the results of our training program are utilized to give thousands of infants a chance for healthy and productive lives.

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Letters to the Editor

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Billing for Neonate Critical Care

By Julie-Leah J. Harding, CPC, RMC, PCA, CCP, SCP-ED, CDIS

Understanding the Basics

Newborn Critical Care

When the newborn is critically ill or injured, there are specific neonatal critical care CPT codes for reporting the services that are rendered during the initial critical care, subsequent critical and inter-facility transport. Reporting these CPT codes requires attention to detail when more than one physician is providing care for the infant; i.e. which physician reports which CPT codes.

Inpatient Neonatal Critical Care

For the initial day of critical care of a critically ill neonate, 28-days of age or less, is reported with CPT code 99468. Only one physician may report this CPT code. If another physician provides critical care services to the neonate on the same date of service, that physician must report the critical care services with CPT codes 99291-99292. These CPT codes are often used for patients over the age of 72 months old. This often causes confusion when billing for critical care.

When critical care services are provided to neonates or pediatric patients less than 6 years of age at two separate institutions by an individual from a different group on the same date of service:

- the individual from the referring institution should report their critical care services with the time-based critical care codes (99291, 99292) and
- the receiving institution should report the appropriate initial day of care CPT code 99468, 99471, 99475 for the same date of service.

"When the newborn is critically ill or injured, there are specific neonatal critical care CPT codes for reporting of these services that are rendered during the initial critical care, subsequent critical and inter-facility transport"

99468 - Initial Inpatient Neonatal Care, 28 days or younger
99469 - Subsequent Inpatient Neonatal Care, 28 days or younger
99471 - Initial Inpatient Pediatric Critical Care, 29 days through 24 months of age
99472 - Subsequent Inpatient Pediatric Critical Care, 29 days through 24 months of age
99475 - Initial Inpatient Pediatric Critical Care, 2 to 5 years of age
99476 - Subsequent Inpatient Pediatric Critical Care, 2 to 5 years of age
99477 - Initial Inpatient Intensive Critical Care (not critically ill), 28 days or younger
99478 - Subsequent Inpatient Pediatric Critical Care (not critically ill), very low birthweight infant of less than1500 grams
99479 - Subsequent Inpatient Intensive Care Services (not critically ill), very low birthweight infant of less than 1501-2500 grams
99480 - Subsequent Inpatient Intensive Care Services (not critically ill), very low birthweight infant of less than 2501-5000 grams
• These CPT Codes predominantly are age based, others by weight • Time does NOT need to be captured

When a critically ill neonate or pediatric patient improves and is transferred to a lower level of care,

- the transferring physician reports subsequent hospital care (99231–99233) or hourly critical care services (99291–99292) as appropriate based on the condition of the neonate or child.
- the receiving physician reports subsequent intensive care (99478–99480) or subsequent hospital care (99231–99233) services as appropriate.

Subsequent neonatal critical care days are reported per day with CPT code 99469. Just like the initial critical care, CPT code 99468, only one physician may report code 99469 on a given date of service.

Critical Care During Transport

Critical care services delivered by a physician, face-to-face, during an inter-facility transport of a critically ill or injured pediatric patient, less than 2 years old (24 months of age), are reported based on the face-to-face time from when the physician assumes care at the referring facility and ending when the receiving facility accepts the pediatric patient's care. For these services report:

- CPT code 99466 for 30-74 minutes of hands-on care and
- CPT code 99467 for each additional 30 minutes of hands-on care.

Note: Less than 30 minutes of hands-on care during transport would not be separately billable.

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Medical News, Products & Information

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New Scientific Review Reveals Huge Gaps in Understanding Preterm Birth: A Clarion Call to the Scientific Community - More Research Needed to Prevent Leading Killer

Newswise — Preterm birth is the leading cause of death for children under 5 worldwide, and a new scientific paper reveals a startling lack of knowledge about what causes it and how to prevent it.

Published in the November issue of *Science Translational Medicine,* "Prevention of Preterm Birth: Harnessing Science to Address the Global Epidemic" shines a light on the urgent need for a larger, coordinated research effort to discover how to identify women at risk for preterm birth and develop prevention interventions.

"There are not enough resources dedicated to researching the complex problem of preterm birth and its prevention," said lead author Craig Rubens, MD, PhD, Executive Director of the Global Alliance to Prevent Prematurity and Stillbirth (GAPPS), an initiative of Seattle Children's. "This paper is a clarion call to the scientific community, that investing in preterm birth research will pay dividends with millions of lives saved and also save billions of dollars in healthcare expenses associated with preterm birth."

The paper provides an analysis of nine pathways that can contribute to preterm birth, including: genetics, psychological and environmental stress, and infection and inflammation. It notes that approximately 70% of preterm births are spontaneous, and there are few known interventions that can delay labor once it has begun.

"It's easy to look at preterm birth and view it as a single endpoint," Rubens said. "In reality, preterm birth can have many causes and pathways. Although the end result is the same, we need to understand the different pathways so we can develop ways to prevent them."

The authors note that there are many factors that increase a woman's likelihood of a preterm birth – such as periodontal disease, poor pregnancy weight gain, and cigarette use – but there is not much understanding of why different factors increase risk. For example, in the United States, babies of non-Hispanic black women have preterm birth rates that are 40% greater than those of Hispanic and non-Hispanic white women, and this difference persists even after adjustment for maternal socioeconomic status and education. Unfortunately, even less is understood about the risk factors, disparities, and causes of preterm birth in high-burden, low-resource countries.

There is a need for more research "to better understand the biology of pregnancy and how [different] risk factors contribute to preterm birth in order to develop effective strategies for early detection and prevention," the authors write.

The paper distills the state of preterm birth research into a central analysis, while conveying the tremendous burden of preterm birth and the urgent need for more research to understand its causes. The authors point out some major challenges, including the fact that pregnancy research involves studying two individuals – the mother and the fetus – at the same time, as well as the influence of the genetics of the father. They also pose a number of questions that can help lay the foundation for what future research should seek to address and how research can be translated into practical interventions.

Additionally, the paper identifies barriers to pregnancy research, including the perception of risk and liability, which deters scientists and pharmaceutical companies from testing diagnostics and therapeutics during pregnancy.

The authors note, "The gaps in knowledge about the basic biology of both term and preterm pregnancy, including what constitutes normal gestational length in any given population, leave clinicians with few tools to prevent [preterm birth]. This is the fundamental reason that most prematurity intervention efforts are actually aimed at care of the woman in preterm labor and care of the preterm neonate, rather than prolonging gestation or stopping labor."

Every year, more than 15 million babies are born too soon around the world, and more than one million of them don't survive infancy. Even in high-income countries with advanced medical technology, preterm birth remains the leading cause of infant mortality. In the U.S., 1 in 9 babies is born too soon, and studies have found that preterm birth costs society more than $26 billion a year in the U.S. alone.

Birthweight Charts Tailored to Specific Ethnic Groups May Be Better Predictor of Adverse - Immigrant women Give Birth to About One-third of the Babies Born in Ontario

Immigrant women give birth to about one-third of the babies born in Ontario. Yet clinicians still measure those babies before and after birth using the same scales that measure babies whose mothers were born in Canada, often of Western European ancestry.

As a result, many babies born to immigrant mothers, especially those from South and East Asia, may be incorrectly labelled small for their gestational age or large for their gestational age, according to research published in the *Canadian Medical Association Journal.*

Those designations can trigger medical interventions, such as heightened monitoring and follow-up care for small babies, which may not be necessary, said Dr. Marcelo Urquia, an epidemiologist at the Centre for Research on Inner City Health of St. Michael's Hospital and an adjunct scientist at the Institute for Clinical Evaluative Studies. Or, they may miss large babies associated with complicated deliveries.

Dr. Urquia and colleagues have developed a series of birthweight curves for specific regions of the world--graphs used to plot how one newborn's weight compares to others. A baby whose birthweight is in the lowest tenth percentile of the curve is deemed to be "small for gestational age." One whose birthweight is in the highest tenth percentile is deemed to be "large for gestational age."
Dr. Urquia looked at 1,089,647 single births in Ontario between 2002 and 2012. About one-third of those babies (328,387) were born to immigrant mothers, of whom more than half (53.6%) were of East and South Asian origin.

About 10% (33,780) of infants born to immigrant mothers were classified as small for gestational age on both the Canadian and regional scales. These babies were more likely to die or suffer adverse events than heavier infants, Dr. Urquia said.

About 6% of additional infants born to immigrant mothers were classified as small for gestational age on the Canadian curve, but not on the birthweight curve for the mother's country of origin.

Compared to newborns of Canadian-born mothers, newborns of immigrant mothers classified as small for gestational age on the Canadian curve had lower odds of adverse events such as a lengthy hospital stay

or death. But babies classified as small on the world-region specific curves were more likely to die or suffer from adverse events.

Approximately 5.4% of babies of immigrant mothers were deemed large for gestational age when using both curves and about 4.3 % were classified as large when using only the world-region specific curves. These deliveries of babies missed by the Canadian curve also exhibited complications associated with large babies, such as perineal tears in the mother, shoulder dystocia (when the baby's shoulder gets stuck behind the mother's pubic bone, preventing easy delivery) and postpartum hemorrhage.

"World region-specific curves seem more appropriate than a single Canadian curve for assessing the impact of small for gestational age and large for gestational age on adverse neonatal and obstetrical outcomes among some immigrant groups, particularly those whose birth weight distributions differ markedly from that of the local population, such as East and South Asian immigrants," Dr. Urquia wrote.

"Estimating the number of newborns conceivably spared unnecessary prolonged stay in hospital, special care, or referral for specialized pediatric or nutritional interventions and the cost savings therein, is a worthwhile step in evaluating the impact of adopting world region-specific curves among certain immigrant populations."

March of Dimes Calls for 50% Reduction in Preterm Births by 2030

The March of Dimes is calling for a nationwide effort to reduce U.S. preterm births to 5.5% of all live births by 2030. Seven other developed countries already have preterm birth rates below 6%, and 15 have rates below 7%. The U.S. rate of 11.4% in 2013 is one of the highest. The U.S. ranked 37th out of 39 high resource countries in 2010.

"The United States spends more money per capita on health care than almost any other country in the world, and yet our premature birth rate and our infant mortality rate are among the highest." says Dr. Jennifer L. Howse, President of the March of Dimes. "The U.S. should aspire to be among the best globally in preterm birth rates and give all our children a healthy beginning."

Writing in an article in Pediatrics published online today, Dr. Howse and her coauthors assert that the goal can be achieved by optimal use of known interventions and by studying countries with better outcomes. Interventions and risk reduction strategies known to prevent premature birth include:

- Eliminating early elective deliveries before 39 weeks of pregnancy
  Optimizing birth spacing (18-23 months between pregnancies)
  Helping women quit smoking
- Offering progesterone treatments for all women with a prior preterm birth.
- Reducing multiple births by following fertility treatment best practices
- Offering low-dose aspirin to prevent pre-eclampsia in women with high risk pregnancies.

The authors also call for expanded funding for research to discover the unknown causes of premature birth and identify new interventions. The March of Dimes is funding a network of Prematurity Research Centers that currently include Stanford University, and a consortium of universities in Ohio including University of Cincinnati, The Ohio State University, and Case Western Reserve University. Two new research centers will be announced later this month.

Premature birth (before 37 completed weeks of pregnancy) is a serious health problem that costs the United States more than $26 billion annually, according to the Institute of Medicine. It is the leading cause of newborn death. Babies who survive an early birth face a higher risk of lifetime health challenges than babies born full-term, such as cerebral palsy, visual and hearing impairments, and intellectual disabilities.

About 450,000 babies out of nearly four million live births were born too soon in 2013 in the United States. Had the US achieved a rate of 5.5% in 2013, the number of babies born preterm could have been reduced by half. A rate of 5.5% would move the U.S. ranking to the top 10% of high resource countries.

For the latest resources and information, visit marchofdimes.org or nacersano.org.

Revolutionary Software Helping Overhaul Inefficient Healthcare Delivery, Improve Patient Safety and Outcomes

Newswise — Challenged with cutting expenditures while delivering better care within the world's most expensive healthcare system, U.S. hospitals are increasingly turning to time-motion studies (TMS) - a technique that reveals how inefficiencies and irregularities in workflow impact costs and patient outcomes.

Despite the introduction of dozens of TMS software programs in the last decade, no single platform has gained traction, primarily because many were developed for individual projects with limited features that offered little benefit over the traditional TMS method of capturing data with a stopwatch, pen and paper.

"Issues in existing TMS software programs make the data from them questionable, difficult to analyze and impossible to compare across institutions," said clinical workflow expert Marcelo Lopetgui, MD, MS in The Ohio State University College of Medicine Department of Biomedical Informatics. "TMS are such powerful tools for guiding resource and training decisions, but the current software really holds back their potential for providing insights into healthcare delivery problems."

Stunned at how an efficiency-driven process had become so inefficient, Lopetegui, a physician-turned -biomedical informatics researcher, decided TMS software needed more than an upgrade, but a complete overhaul that would change the way it looked, functioned and performed.

Having honed his programming skills developing websites for friends in medical school, Lopetegui developed a software platform called TimeCaT (Time Capture Tool) that solves existing software problems with mobility, user interface, and data collection, analysis and validation – areas that had never before been standardized in TMS, ultimately threatening the accuracy and usefulness of previous studies.

"If you conduct a study on how long ICU staff takes to sanitize their hands between patients in order to help reduce infection rates and your observers are clocking the same activity from different start points – the data will be wrong. It sounds simple, but if resources are allocated or changes made based on inaccurate information, you haven't solved the problem and have potentially made it worse."

With an open access, web-based platform, TimeCaT has relied on user feedback to help the program evolve and improve. Since 2010 the team has been releasing new versions of TimeCaT to what they call the "TimeCAT community," a consortium of approximately 50 users spanning ten major universities on three continents.

TimeCaT's supporters continue to grow as Lopetegui and others have given presentations and published studies about the software's use in areas ranging from ambulatory care to emergency

medicine, proving that TimeCaT is flexible enough to apply to a diversity of clinical settings.

Department of Biomedical Informatics Chair, Philip R. O. Payne, PhD, who recruited Lopetegui from Chile and was his post-doc mentor, says that TimeCat's greatest accomplishments have been to raise the bar on what scientists can expect from TMS, and offer reliable data that can shape and improve medicine worldwide.

"TimeCaT is allowing us to systematically and rigorously collect data on how people perform their jobs while interacting with technology, their environment and their coworkers in a way that wasn't possible before," said Payne, who is also the inaugural Director of the Data Analytics Collaborative, which is part of the Discovery Themes initiative at Ohio State. "It represents the best of what biomedical informatics has to offer: a human factors approach to making sense out of massive amounts of data in order to improve the delivery of safe and cost effective health care."

Making TMS, technology work harder – and smarter

Lopetegui's first step to improve TMS software was to make the data collection process easier and less error-prone. He made TimeCaT a web-based platform that was able to work on any internet capable device, harnessing mobile and touch-screen technology that lets observers keep their eyes on the activity.

He included other features that many digital TMS systems don't have, such as a simple graphical user interface, the ability to correct an order collection error in the field, automated time stamps to make workflow analysis more accurate, and cloud-based data collection that allows offsite researchers to track incoming data from around the world in real time.

Another major flaw TimeCaT addresses is observer validation, which among TMS is often challenging. TimeCaT is programmed with one of the first-ever inter-observer validation algorithms. The tool allows researchers to perform a test run of their study to gauge the accuracy of the eyewitnesses and to conduct on going validity tests throughout the data collection.

Lopetegui was also the first to try to introduce a standard taxonomy, or language, to TMS, that would prompt researchers to use a common set of terms to describe tasks, which enables scientists – for the first time – to accurately pool data from multiple studies.

"The action of "hand-washing" has literally been described a dozen different ways," said Lopetegui. "On the website researchers can find out what terms have already been used, or share their own for others to use. This and other features make it possible for researches to reliably aggregate and compare data across thousands of study locations."

Lopetegui says that the team will continue to roll out new versions of TimeCaT with expanded features, many of which have been suggested and then tested by the community – which has grown beyond the healthcare realm.

"We have had a professional soccer team use TimeCaT to see if they could improve their game," said Lopetegui. "I'm not sure if it worked for them, but it was the perfect validation for me that we had created something truly accessible, functional and adaptable."

TimeCaT was developed with support from Ohio State's Center for Clinical and Translational Science (CCTS). Collaborators include Philip Payne, PhD, FACMI Professor and Chair, Department of Biomedical Informatics and Director of the Data Science Cluster for the Ohio State CCTS; Po-Yin Yen, RN, PhD, Assistant Research Professor of Biomedical Informatics; Albert Lai, PhD, Assistant Professor of Biomedical Informatics Peter Embi, MD, MS, Associate Professor and Vice-Chair, Department of Biomedical Informatics and Chief Research informatics officer for Ohio State's Wexner Medical Center.

For more information about educational opportunities, research projects and funding opportunities within the Department of Biomedical Informatics, please contact Biomedical.Informatics@osumc.edu.

The Ohio State University Center for Clinical and Translational Science (CCTS) is funded by the National Institutes of Health (NIH) Clinical and Translational Science Award (CTSA) program (UL1TR001070, KL2TR001068, TL1TR001069) The CTSA program is led by the NIH's National Center for Advancing Translational Sciences (NCATS). The content of this release is solely the responsibility of the CCTS and does not necessarily represent the official views of the NIH.

NEONATOLOGY TODAY

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ISSN: 1932-7129 (print); 1932-7137 (online).
Published monthly. All rights reserved.

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8100 Leaward Way
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Manzanita, OR 97130 USA
www.NeonatologyToday.net

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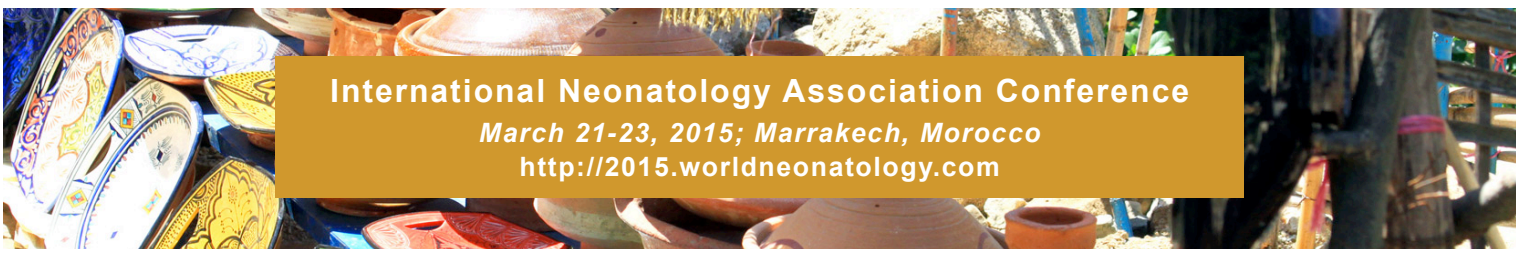

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In 2010, PAMC NICU received the John M. Eisenberg Award from The National Quality Forum and The Joint Commission for innovation in patient safety and quality. This NICU has an average daily census of 40-45, approximately 570 admissions annually and a certified NNP-staffed neonatal transport program. As the only Level-III NICU in Alaska, it serves as the regional referral center for the entire state including the Alaska Native and U.S. military populations.

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