ROLE OF MEDICAL LABORATORY SCIENCE IN MATERNAL AND CHILD HEALTH – A REVIEW

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Abstract
Medical Laboratory Science (MLS) is integral to many clinical decisions on prevention, diagnosis, treatment and management of patient disease. Laboratory tests supply clinicians with information necessary to provide high quality, safe, effective and appropriate care to patients. Medical Laboratory Services are an essential component of Health care and can be utilized effectively at every level of health care delivery. MLS plays a significant role in Maternal and Child Health (MCH). The Medical Laboratory Science objective of the Maternal, Infant, and Child Health addresses a wide range of conditions that affect the health, wellness, and quality of life of women, children, and families. In clinical laboratories, Medical Laboratory Scientist perform a full range of Laboratory tests as far as MCH care is concerned from; simple Pre- marital blood tests, to more complex tests to uncover diseases such as AIDS, diabetes, and cancer, typing patients and blood products for transfusion, as well as MCH interventions through programmes that deliver integrated packages of services (e.g. antenatal care, well child care, integrated management of childhood diseases, Vaccine Preventable Diseases (VPDs), Malaria, and respiratory diseases, identification and management of infants and children with sickle cell disease, screening newborns for devastating disorders, such as phenylketonuria, that can be prevented by early intervention; or developing the capacity to determine the levels of chemicals constituents in blood and body fluids, classify cells for abnormalities and uncover markers for cancer and inherited genetic diseases. Due to the changing world of Laboratory technology, while so many tests are now offered through kits help to reduce turnaround time, Medical Laboratory Science ensure these tests are being performed with quality by trained professionals.
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Medical Laboratory Science in Healthcare Delivery

Medical Laboratory Science profession is "the practice involving the analysis of human and animal tissues, body fluids, excretions, production of biologicals, design and fabrication of equipment for the purpose of Medical Laboratory diagnosis, treatment and research" (Glen, 2015).

Medical Laboratory Science is essential for monitoring threat to clinical practitioners who depend on Laboratory Science to diagnose and monitor disease in individuals. With the use of advanced skills and sophisticated biomedical instrumentation, Medical Laboratory Scientists work behind-the-scenes to provide essential information for effective interventions; whether monitoring emerging infectious diseases, such as avian influenza globally; identifying pathogens, such as *Escherichia coli*, confirming the accuracy of test results and monitoring the quality of testing procedures (Karen and Nicholson, 2006). Medical Laboratory has been instrumental in identifying newly recognized or re-emerging microbes that caused outbreaks, including *Legionella* (McDade, 1977),

Hantavirus, West Nile virus and severe acute respiratory syndrome-associated coronavirus; SARS-CoV (Ksiazek *et al*., 2003).

Medical Laboratory Science is central to the operation of many hospitals today (Karen and Nicholson, 2006). The practice of modern medicine would be almost impossible without Medical Laboratory Science knowledge, which is used to determine the presence, extent or absence of disease (Karen and Nicholson, 2006). Speciality areas in Medical Laboratory Science include Clinical Chemistry, Haematology and Blood Group Serology, Histopathology, Medical Microbiology and the emerging field of Molecular Diagnostics (Plebani and Panteghini, 2014). It is estimated that 70-80% of Physician decision on any one patient is based on Laboratory test data (Plebani and Panteghini, 2014). An effective Medical Laboratory Service is an essential part of a functional Service to healthcare and to society as a whole (Wolcott *et al*., 2015).

Medical Laboratory Scientists in the Health Care World

By combining the unique talent of performing quality Laboratory assays with knowledge of the patho-physiologic rationale behind the tests, Medical Laboratory Scientists have the expertise in regard to the appropriate test selection and interpretation of Laboratory results (Glen, 2015), thereby creating opportunities to define the added value and the role of Medical Laboratory Science on Healthcare Delivery (Simona *et al*., 2015)**.** Medical Laboratory Scientists do much more than examine specimens through a microscope. They operate complex electronic equipment, computers, and precision instruments (CHPES, 2003).

Although unrecognized and usually unappreciated by many, Medical Laboratory Scientists are professionals with sophisticated knowledge in their field, and who make a significant contribution by helping to save lives in an inconspicuous way (Scott *et al*., 2015). A Medical Laboratory Scientist's work is broader and more intricate than one might think. Preparation of a donor's blood for transfusion to a patient is just one aspect of their work. One of the basic and most common tests done by these professionals is a complete blood count or FBC. From this, doctors will know if a patient has an acute infection, Anaemia, Leukaemia, or other Blood-related illnesses (Adeli, 2013). Laboratory results are then interpreted usually as normal or abnormal. And in turn, the doctor will decide whether to do a confirmation test, follow up test, or to do a treatment on the patient. Therefore "Medical treatment is nearly impossible without the diagnostic information provided by the Unsung Heroes; Medical Laboratory Scientists of Medical Laboratory science" (Rodney and Stephanie, 2016).

Medical Laboratory Scientists are self-sufficient, precise and thorough (David, 2015). They are trouble-shooters who not only report accurate results, but also know when results are incorrect and need to be rechecked. Quality is not just important; it is essential (David, 2015). The patient deserves nothing less (David, 2015). Whether working in a forensic or research Laboratory, they provide critical information in all areas of health and medicine (Forsman, 1996). The Medical Laboratory Scientists has the best of both worlds with the challenges and rewards of Medicine and Science.

Maternal and Child Health

Maternal and Child Health (MCH) care is the health service provided to mothers; women in their child bearing age and children (Raghupathy, 1996). The targets for MCH are all women in their reproductive age groups (15 – 49) years, children, school age population and adolescents (Raghupathy, 1996). Throughout the world, especially in the developing countries, there is an increasing concern and interest in Maternal and Child Health care (Raghupathy, 1996).

Medical Laboratory Science play a significant role in MCH interventions through programmes that deliver integrated packages of services (e.g. antenatal care, well child care, integrated management of childhood diseases, Vaccine Preventable Diseases (VPDs), Malaria, and respiratory diseases (CDC, 2013). MLS play a key role in the provision of anti-retroviral (ARV) therapy for HIV infection. The usual immunological indicator used to assess a patient's need for therapy is CD_4 counting and HIV RNA load. MLS support MCH programs such as the elimination of mother-to-child-transmission (MTCT) of HIV; treatment and care for children with HIV; diagnosis, treatment and care of children with malaria; prevention of malaria during pregnancy; Tuberclosis prevention and control, and emerging diseases detection and response (CDC, 2013). Since 2007, CDC has partnered with WHO and strengthened Laboratories and networks to sustain high quality MCH-related diagnostics on the global elimination of MTCT of HIV and congenital syphilis (CDC, 2013), identification and management of infants and children with sickle cell disease, blood typing etc (CDC, 2013).

The specific objectives of MCH Care focuses on the reduction of Maternal, Perinatal, Infant and Childhood mortality and morbidity and the promotion of reproductive health and the physical and psychosocial development of the child and adolescent within the family (Spangler and Bloom, 2010).

Maternal mortality is an adverse outcome of many pregnancies. Miscarriage, induced abortion, and other factors, are causes for over 40 percent of the pregnancies in developing countries to result in complications, illnesses, or permanent disability for the mother or child (Becker *et al*., 1993).

Pregnancy is a normal healthy state, which all women aspire to at some point in their lives (Joy, 2004). Yet, this life-affirming process carries with it serious a risk of death and disability (Joy, 2004). Medical Laboratory Science, ensure quality reproductive and Child Health Services. Antenatal care plays a role in identifying danger signs or predicting complications around delivery by screening for risk factors (Somasundaram *et al*., 2012).

Improving the well-being of mothers, infants, and children is an important public health goal worldwide. Their well-being determines the health of the next generation and can help predict future public health challenges for families, communities, and the health care system (Vijaya, 2015; Catherine, 2015).

Effective Laboratory Services in Maternal and Child Health

The establishment of Safe Motherhood Services is of optimal importance to curtail maternal mortality (Jagdish *et al*., 1995). Services required include elements of Laboratory support. A urine test remains the first test to confirm pregnancy, which determines the HCG hormone levels. As a way of promoting Safe Motherhood and better outcomes for their babies, antenatal screening services for anaemia, HIV, syphilis, Hepatitis and Malaria are pivotal (Metgud, 2009). As part of antenatal screening services, the WHO recommends that all pregnant women have a Haemoglobin (Hb) measurement taken at least once during their pregnancy (WHO, 1994). Haemoglobin measurement is also important in assessing patients with malaria (Medina *et al*., 2005).

Anaemia: affects over half of all pregnant women and children in poor countries (WHO, 1994). Accurate Haemoglobin measurement is the best way to confirm cases (Medina *et al*., 2005). Anaemia is known to give rise to considerable long-Maternal and Child Health Care morbidity in women and at extreme levels may be associated with low birth weight. Anaemia during pregnancy may be aggravated by Malaria, Hookworm infection, and Schistosomiasis. Death from anaemia results from heart failure, shock, and infection due to lowered resistance (WHO, 1994).

Malaria: is a major cause of illness and death in Sub-Saharan Africa (CDC, 2013). Although persons of all ages can get malaria, two groups are at high risk; children under five years of age and pregnant women (Amexo *et al*., 2004). Presently the majority of malaria diagnosis at primary and secondary level facilities is based on symptoms and treated empirically with anti-malarial drugs (Amexo *et al*., 2004). This approach leads to a significant amount of misdiagnosis and may promote development of resistance to the drugs resulting in an urgent need to change the treatment of malaria (Amexo *et al*., 2004). Light microscopy is the "gold-standard" method for detection of malaria parasites in blood films, by Medical Laboratory Scientists (Mundy *et al*., 2000).

Blood transfusion: is an important requirement; with a third of direct maternal deaths resulting from haemorrhage. An effective blood transfusion service is also vital for many activities in the health service - from major surgery to treatment of severe anaemia in children. Screening blood for infection was identified as the most costly processes amongst the critical laboratory services (59% of total costs); but an effective screening system is essential to reduce the risks of transfusion-related infections (Mundy *et al*., 2003); due to the high prevalence of blood-borne disease, particularly viral diseases to ensure that the blood units are safe for the patient, without any life-threatening reactions or complications (Candontti, 2001).

Blood group and Rhesus (Rh) factor: Blood group is important to know, in case of transfusion during pregnancy or birth. Rhesus (Rh) factor status is also significant. A rhesus (Rh) negative means that the mother can develop antibodies against her baby, if it is Rh positive. There is no risk during the first pregnancy, but can be a problem for subsequent babies there may be an immune reaction and production of Rh antibodies (Ochei and Kolhatkar, 2000). This reaction is called Rh sensitization. If Rh antibodies develop, they can, in future pregnancies, attack an Rh-positive baby's blood cells and cause severe anaemia. Pregnant women will therefore be screened for abnormal antibodies during early pregnancy, by Medical Laboratory Scientists, to know their status in order to save the unborn child (Ochei and Kolhatkar, 2000).

Tuberculosis and **HIV:** The diagnosis of Tuberculosis depend microscopic examination of sputum smears (Hargreaves *et al*., 2001; Squire *et al*., 2005). **HIV** can be spread from an infected mother to her baby during pregnancy, birth, or breastfeeding. If an HIV infection is found during pregnancy, there is a 1 in 6 chance of the baby becoming infected (Johnstone, 1992; Mekonnen *et al*., 2003). Getting an early diagnosis is therefore crucial as treatment can reduce the risk of transmission to the baby. An infected mother can also be treated. HIV status is confirmed by a Laboratory test before treatment and response monitored with CD_4 counts (Mekonnen *et al*., 2003). It is the responsibility of Medical Laboratory Scientists to define and communicate critical Laboratory results, a key issue in maximising patient safety (CQHCA, 2000).

Hepatitis B virus: which infects the liver and the infection, is easily transmitted to the unborn child if the mother is a carrier of the hepatitis B virus; when passed on to the baby, will need to be protected with a series of injections of vaccine and antibodies, starting as soon as he is born. A blood test at one year of age is used to check whether he has avoided the infection (Candontii, 2001) thus; carried out by trained Health Professionals called Medical Laboratory Scientists, who have honed their skills and carved a niche for themselves, by performing Laboratory analyses and providing information to physicians and other members of the Health team, thus aiding diagnosis, treatment, monitoring and prevention of diseases (Lil'-Love, 2003).

VDRL: Test to detect a sexually transmitted infection, syphilis which has a grave impact on the foetus, then on the new born. It could cause abnormalities in the child or leads to stillbirth (Ochei and Kolhatkar, 2000).

Diabetes during pregnancy: Gestational diabetes occurs in approximately 1 in 400 pregnancies and some women will remain diabetic after delivery (Kecia, 2015). If glucose is detected in urine then an 'oral glucose tolerance test' (OGTT) is performed: and if glucose levels are raised then a diagnosis is made. An OGTT test is also offered to women with risk factors (overweight, family history of diabetes, women aged over 40 years, women from Asia, North Africa, West Indies, with a history of foetal abnormality).These are achieved using Medical Laboratory science knowledge acquired and impacted in healthcare delivery by Medical Laboratory scientists (Pansini, 2002).

Urinary tract infections: can lead to preterm labour and birth, or pyelonephritis and sepsis (Joy, 2004). The knowledge of **Cytopathology** allows for examination of smears of cells from all over the body (such as from the cervix) for evidence of inflammation, cancer, and other conditions in women especially of child-bearing age (David, 2015).

Pivotal Role of Medical Laboratory Science in Childhood Diseases

Medical Laboratory Science ensures that quality Laboratory Service is not just about providing accurate, useful and timely information to the attending physicians; it must be provided by Medical Laboratory Professionals who have the contextual background to fully and optimally assist the clinician within the context of the particular patient's circumstances (Irwin, 2015), especially concerning MCH care delivery. These professionals perform complex chemical, biological, haematological, immunologic, microscopic, and bacteriological tests. They examine body fluids such as blood, urine, sputum, stool, and cerebrospinal fluid (CSF), as well as other specimens in infants, children and adolescents to ensure that quality patient care is provided for several childhood diseases such as diarrhoeal illness, meningitis, poliomyelitis, respiratory tract infections and other infectious or parasitic diseases, children suffering from genetic disorders including sickle cell anaemia, beta thalassemia etc. up to the age of 18 years (Kenneth, 2010).

Paediatric Laboratory Tests

Clinicians need timely, accurate test data to make faster, more effective patient care decisions. The most vulnerable population is children, many of whom are unable to adequately describe their ailments. Laboratory professionals are the voice of their patients, providing clinicians with the information they need. Medical Laboratory Scientists go to work each day knowing they are helping countless infants, children, and adolescents lead healthier lives (AACC, 2016a). Laboratory tests can detect diseases or conditions before signs and symptoms occur, allowing for treatment before permanent damage is done. This is especially important in paediatrics, as catching problems early in a developing child prevents long-term complications, like cognitive or physical impairment (AACC, 2016a).

Medical Laboratory science is integral to the healthcare of infants, children, and adolescents (Pysher *et al*., 2006). Approximately three billion paediatric laboratory tests are performed in more than 250,000 certified laboratories in the U.S. (Pysher *et al*., 2006; Price and St John, 2014). In the U.S., Paediatric Laboratory screening begins within 48 hours of birth for more than four million infants per year. Paediatricians and family practice physicians rely on Laboratory screens and tests to ensure the health and well-being of their patients from birth through adolescence (Hopkins, 2013; CDC, 2014).

Newborn Screening

Newborn screening (NBS) is a premier public health programme that identifies newborns that may appear healthy immediately after birth, but may have a severe-but-treatable congenital or inherited genetic disorder (USDH, 2016). Early Laboratory testing through initial newborn screening leads to faster life-altering interventions (Hopkins, 2013; AACC, 2016a).

If the screening identifies an abnormal result; it is conveyed to the physician, to make an appropriate medical referral for additional confirmatory diagnostic testing to be performed (AACC, 2008).

Bilirubin: test might be ordered on infants who appear jaundiced. Bilirubin is a by-product of the normal breakdown of red blood cells and its build up in the blood results in the characteristic yellow skin and eye discoloration of jaundice. Most two-to-four-day-old newborns have mild jaundice, but as the liver matures this naturally dissolve within one to two weeks (LabTest Online, 2015; TNF, 2016). If untreated, very high bilirubin levels can cause brain and central nervous system damage that can result in seizures and permanent hearing loss, Laboratory test is required to determine whether bilirubin levels are sufficiently high to warrant treatment (LabTest Online, 2015).

Phenylketonuria (PKU): a treatable genetic disorder screened to enable preventative treatment. The condition is characterized by the inability of the body to breakdown phenylalanine, an amino acid found in protein-based foods. If untreated, it can lead to irreversible brain damage (AACC, 2008). Medical Laboratory professionals developed the PKU screen in response to the then-emerging scientific knowledge of how PKU develops and the ongoing clinical need for the test (CDC-USDH, 2013).

Cystic Fibrosis (CF): causes severe damage to the lungs and the digestive system in newborn. CF is caused by defects in a protein that controls the movement of salt in and out of cells causing lung infections and intestinal problems, due to thick mucus in the airways and the pancreas. Babies with a positive screen for cystic fibrosis are referred to specialized paediatric testing centers for confirmatory testing (Lab Test Online, 2015). Then, Laboratory may confirm the diagnosis by measuring chloride in a patient's sweat, and if affected, the child is started on life-long treatment (Lab Test Online, 2015).

Childhood Illnesses

Children's diseases are often unique and different from adult disorders. Specialized Laboratory tests are required to accurately diagnose, treat, and manage these diseases. Many childhood illnesses are caused by infectious agents. Although vaccinations have tremendously decreased the incidence of a number of previously common infectious diseases, infections still remain the leading cause of childhood illnesses (Lab Test Online, 2013).

Paediatricians may request children (0 to 12 years old) be screened for diabetes, obesity, high cholesterol, tuberculosis, iron deficiency anaemia and lead poisoning, depending on determined risk. According to the CDC, about 250,000 children between one and five years old have blood lead concentrations above recommended levels (Lab Tests Online, 2013b). Additionally, the rate of obesity has more than doubled in children and quadrupled in adolescents during the past 30 years, increasing the number at risk for cardiovascular disease and diabetes (CDC, 2015). Screening children for lead exposure is an example of how the judicious use of Laboratory tests has vastly improved public health. Lead is a poison that is found in the environment as a result; exposure to lead can cause irreversible cognitive damage (Lab Tests Online, 2013b). Children are more susceptible to lead toxicity than adults because they have not fully developed the metabolic system to eliminate lead from their bodies efficiently. Young children are also more likely to be exposed to lead because they play and crawl on the floor and have tendencies to ingest non-food objects, like paint chips. The impact of lead poisoning to the brain and overall development may not be apparent until long after the exposure occurs (Lab Tests Online, 2013b). However, Laboratory testing can detect lead in a child's blood, so treatment can be initiated to remove lead from the child, and action can be taken to eliminate the source of the lead from the child's environment (CDC, 2015).

Respiratory Syncytial Virus (RSV): infection can cause airway inflammation and pneumonia, and streptococcus bacterial (strep) infection; a leading cause of sore throat. Since children, particularly newborns, do not have fully developed immune systems, prompt diagnosis is required. To diagnose these and other infections, Laboratory professionals generally use rapid screening tests that provide quick preliminary diagnosis for early patient management (Lab Tests Online, 2013a). Definitive tests are used to confirm the results of screening tests. For example, a rapid strep test can provide results within a few minutes from a patient throat swab. If the test is positive, the physician prescribes antibiotics and treatment can begin immediately, minimizing disease duration and the risk of the patient spreading the infection to others (Lab Tests Online, 2013a).

Type1diabetes: A child's body cannot make a hormone called insulin. This hormone is needed to process the sugar glucose, which is a primary source of the body's energy. Patients with Type 1 diabetes have increased glucose in the blood and urine. If untreated, Type 1 diabetes can lead to serious complications, such as heart, kidney and eye disease (Lab Tests Online, 2013b). Medical Laboratory Scientists play an important role in the diagnosis and treatment of diabetes. They develop sensitive and precise laboratory and point-of-care glucose tests. They invest time and resources into the development of reference intervals and they collectively collaborate on standardization and harmonization initiatives, to ensure accurate test results (Pansini, 2002; Lab Tests Online, 2013b).

Paediatric Reference Intervals

To interpret laboratory results, clinicians rely on reference intervals developed by Medical Laboratory professionals. Reference intervals, sometimes called the "normal" range, are the set of values for any given Laboratory test that would be expected in a healthy person (AACC, 2016b). If a patient's test result falls outside a reference interval, it can provide a clue to the clinician regarding potential disease in the patient. Without precise reference intervals that accurately reflect the healthy range, physicians may misdiagnose a condition, which could result in patient harm and increased healthcare costs (AACC, 2016b). Medical Laboratory professionals have long recognized that reference intervals in children differ not only from those for adults, but also amongst themselves, as the intervals will vary at different developmental stages. Alkaline phosphatase, an enzyme found at high levels in both the bone and liver, provides a classic example of how reference intervals in healthy children and adults dramatically differ. In adults, elevated levels of alkaline phosphatase typically indicate liver or bone disease. In children going through puberty, it is normal to have high levels of alkaline phosphatase in the blood, due to bone growth. During growth spurts, levels may reach particularly high levels. A standard reference interval for alkaline phosphatase in a healthy adult male is 53-128 U/L. However, an appropriate reference interval for alkaline phosphatase in a healthy 14 year old boy is 54-369 U/L (Burtis *et al*., 2012). Therefore, a result of 300 U/L could trigger a misdiagnosis in a 14 year old boy if the physician relies on the reference interval for a healthy adult male (Burtis *et al*., 2012; AACC, 2016b).

Since quality patient care is synonymous with saving a patient's life, Medical Laboratory Science is indeed a great career – a noble profession tethered with a duty to save lives. They may be working in the shadows, but they have been humbly saving lives (Ferdinand, 2010; Sunews, 2011).

Recommendations

- The Medical Laboratory Science and Medical Laboratory Science professionals should provide a unique opportunity to increase public understanding and appreciation of the importance of Pre-marital Laboratory screening tests, to avoid diseases/conditions that affect the health, wellness, and quality of life of women, children, and families.

- Antenatal screening and early laboratory testing through initial newborn screening should be encouraged; as it leads to faster life-altering interventions for the mother and child.
- It is essential that test reports are reliable, standardized, provide the information required, at the time it is needed and in a form that can be understood. It becomes necessary; therefore that such a duty should not be handled by untrained and non-professional staff without adequate supervision.
- Reference intervals that accurately reflect the healthy range should be provided to physicians to aid diagnosis, particularly in children.
- Professionalism among healthcare professions; and improved collaboration among healthcare professionals can lead to improved diagnosis and reduce diagnostic error:

Conclusion

The Laboratory has a critical role to play in supporting the delivery of Maternal and child Essential Health Package, but the resource requirements of a Laboratory service and a lack of understanding of how they function can be barriers to allocating adequate support. However without an effective Laboratory Service, patient diagnosis and care is often compromised, expensive drug treatments are squandered, diagnoses are missed and information about Public Health is inaccurate. It is also impossible to measure the true effectiveness of interventions and to conduct accurate disease surveillance.

Medical Laboratory Science is a vital, dynamic, evolving field. Laboratory Scientists continually work to develop new and better tests to more quickly identify and diagnose medical conditions and diseases, improving patient care and reducing overall healthcare costs. As Medical Laboratory Science continues to advance and increase in promise and complexity, the collaborative development of clinical practice guidelines will be critical to ensure diagnostic advances are appropriately applied. Guidelines provide clinicians with vital information and direction for diagnosing and treating their patients, and laboratory tests are often critical components of decision-making.

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