Mobile Ultrasound Patrol Project

MOROCCO

Special thanks to all the physicians, nurses, midwives, government representatives and all the kind people helping us on the ground in Morocco. To all the generous contributors from WHO and UNFPA. To our in-kind sponsors SONY and SonoSite for lending us the devices and for contributing expertise and insight. To Johanna Woller Melin, John Axel Eriksson, Tomas Hagenfeld and the rest of the Trice Team. To Angela Baker, Moheb Ramsis and the Qualcomm Wireless Reach team for the funds and support. To Doctor Larry Platt for valuable advice. To Karrie Gottschild for endless editing. To Petra Maison for the great graphics. To the Seventy Agency for a beautiful project website. For a comprehensive list of all participants please go to www.mobileultrasoundprojects.org

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Contents

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We believe that the power of advanced wireless technologies can transform lives, and help save them. Qualcomm Wireless Reach™ and Trice Imaging are pleased to present the results of the Mobile Ultrasound Patrol Project, a year-long collaboration that focused on providing mothers in rural Morocco with quality, time-sensitive ultrasound scans at a competitive price. In this report, we share the outstanding results.

Projects like these are critical; every day, around the world, approximately 800 women die from preventable causes related to pregnancy and childbirth. 40% of those deaths are due to injuries or conditions related to placenta complications. We know that maternal mortality is higher in women living in rural areas and among poorer communities.

Today, there are more than 7 billion mobile connections globally; wireless technology is not just an enabler, it is a multiplier and game changer. This is especially true within the healthcare industry. 3G mobile broadband technologies can enable point-of-care devices to provide access to information, help lower costs, facilitate remote care, increase efficiencies and better connect people to their healthcare providers. We want to encourage solutions that improve efficiencies and bring quality care to even the most remote locations because everyone deserves to be healthy.

At Qualcomm, we know that mobile is revolutionizing the way people communicate, share and consume information. Access to advanced wireless technologies has become more prevalent around the world, and we believe this can improve people's lives, especially through progress made in the mobile health or mHealth field. The impact of mobile technology transcends geographies and socioeconomic classes, and we see unprecedented opportunity to extend healthcare resources globally and provide communities with unparalleled access.

Trice Imaging is committed to contribute to a greater and healthier world by shortening the distance between someone in need of a medical diagnosis and those who can provide one. New technologies open up new possibilities to provide healthcare where it has not previously been available, in a time and cost efficient manner. The United Nations, WHO and other global health organizations all agree that high quality of care is a human right. Should an ultrasound be included in that right?

We look forward to the discussions this project will spark, and to focusing our attention on how to accelerate mHealth adoption across the globe.

Sincerely,

Shawn A. Covell, Vice President of Government Affairs
Qualcomm, Inc.

Asa Nordgren, CEO and Co-Founder
Trice Imaging, Inc.

Foreword

Every day, around the world, approximately 800 women die from preventable causes related to pregnancy and childbirth. Nighty nine % of all maternal deaths occur in developing countries and the rate is higher among women living in rural areas, and in poorer communities. Improving maternal health is one of the eight United Nations (UN) Millennium Development Goals[1] (MDGs) adopted by the international community in 2000. Under MDG5, countries committed to reducing maternal mortality by three quarters between 1990 and 2015. Severe bleeding is one of the leading reasons women die in childbirth. The only way of detecting abnormal placenta challenges is via an ultrasound[2].

Ultrasound medicine is experiencing drastic changes, resulting in a veritable paradigm shift. New technology is disrupting how ultrasound imaging is currently executed by whom and at what cost. Technology creates additional access, reduces costs, which is driving accessibility and paves the way for new, sustainable models of healthcare economics.

Four important elements are driving disruption in ultrasound medicine.

- The latest ultrasound devices are smaller in size and connecting wirelessly to the Internet via Bluetooth, Wi-Fi or cellular technologies. Devices can now fit in a physician's pocket or even a folder. According to Harvey Klein, a leading analyst in the industry, the portable ultrasound segment is expected to grow by 13% between 2010 and 2015[3], compared to the sales projections of larger devices, which will grow only 6% over the same time period. Smaller devices are easier for sonographers, physicians, nurses and midwives to transport when traveling to patients; they are also more affordable. This makes ultrasound image-capturing convenient in places where it wasn't previously available or economically feasible.
- Mobile networks are out-pacing fixed networks in terms of availability, speed and capacity. Mobile networks make it possible to remotely transmit data, such as ultrasound studies, from a device to another location. The transferring of big data files that no longer rely on local networks changes the model for diagnostic work.
- Modern technology makes it possible to encrypt data, protect patient records, store regulation-compliant data, and safely authenticate users. This means that while image capturing takes place in one location, analyzing and reviewing that data can take place in a different location without conceding time or compromising the quality of the image.

An increased focus on women's health matters around the globe inspired a wide variety of women's healthcare initiatives. Maternal and child health are at the core of the Alma-Ata Declaration on Primary Healthcare[4] that has been reaffirmed by the World Health Organization (WHO), the United Nations Children's Fund (UNICEF) and the United Nations Population Fund (UNFPA.) Both the MDGs and the Alma – Ata Declaration are the subject of the United Nations Global Strategy for Women's and Children's Health[5]. These advances in ultrasound and mobile technology play a significant role in reducing maternal and child deaths around the globe.

> "We often talk about the great power of technology to transform and save lives of women and girls. This is a very good example of that power,"
>
> *Erin Anastasi, Technical Specialist and PHD in Public Health at UNFPA.*

The Mobile Ultrasound Patrol Project

Inspired by the UN initiatives and the knowledge that their combined strengths could truly impact the health of women across the globe and specifically in Morocco, a group of companies combined resources, talent, and passion for mobile healthcare to create something extraordinary: the Mobile Ultrasound Patrol Project.

- SonoSite Fuji Film provided the ultrasound equipment
- Sony provided the mobile phones and tablets used in the project
- Trice Imaging Inc., a world leader in mobile imaging solutions, initiated and managed the project
- Qualcomm Wireless Reach™ was the main project funder and provided project management support

The goal of the Mobile Ultrasound Patrol Project in Morocco was to validate how advanced wireless technologies and connected portable ultrasound devices can provide access to state-of-the-art imaging diagnostics in places it has never been available before, at a significantly lower cost.

Medical professionals provided proper care to patients in remote areas using encrypted mobile devices that were connected to a 3G/4G network and a sharing platform that enabled experts to perform remote diagnoses. The time and cost efficiencies gained, without any compromise in quality improved the likelihood for early detection and treatment of the major causes of maternal morbidity/mortality, which could ultimately reduce the number of maternal and child deaths.

Key findings of the project:

- Reduced diagnostic review time from two weeks to less than 24 hours
- Reduced diagnostic cost from $80 to $2 USD per patient
- Reduced transportation time of the medical data for review from four days to two seconds
- Increased the medical practitioners' (midwives, nurses and general practitioners) skills to deliver ultrasounds from 20% sufficient for diagnostic purposes to 92% sufficient for diagnostic purposes
- Of the 575 studies completed, 94 cases exposed complications or uncertain diagnosis in which the patients needed to be referred for further care. These cases would not have been detected without access to this specific technology
- The physicians also reported an increase in the number of patients seeking care at the health houses after the trial period was complete. The number of deliveries in these facilities increased, which is important, as it increases the amount of births attended by skilled birth attendants

Background

The problem, in numbers[6]

MDG4, to reduce child mortality, and MDG5 were specifically developed to support two highly vulnerable groups: children under the age of five and women of childbearing age. Indicators under other MDGs also highlight the role of these two population segments in a country's development.

Morocco's population composition indicated particular weakness in MDG4 and MDG5[7]

- 32.7 million inhabitants
- 27% (8.8 million) are children under 15 years of age
- 9% (2.87 million) are children under five years of age
- 29% (9.2 million) are women of childbearing age
- 646 registered births per year
- 2.4 children per woman (fertility rate)
- 720 maternal deaths per year
- 2% (20 per 1,000 live births) neonatal mortality rate
- 2% (20 per 1,000 live births) still birth rate

In 2013, Morocco expected 654,824 births at the national level with 335,553 in urban areas and 319,367 in rural areas.

Child mortality

Child mortality is deeply connected to all other MDGs: extreme poverty, gender inequalities in education, inadequate sexual health education for girls and women, the spread of HIV/AIDS and other diseases, and non-sustainable environmental practices. Each one is a major contributor to poor and dangerous living conditions for children. Across the globe, more than 3 million newborn babies die every year and an additional 2.6 million babies are stillborn[8].

The world made substantial progress towards reducing child mortality under MDG4. The latest figures for under-five mortality from the UN Inter-agency Group for Child Mortality Estimation show a 35% decline in the global rate, from 88 deaths per 1,000 live births in 1990 to 57 in 2010.

There was a significant decrease in the under-five mortality rate (U5MR) in Morocco. The U5MR declined by 60% between 1990 and 2011 and the neonatal mortality rate declined by 46% in the same period.

Maternal and Child Mortality in Morocco[9]

Basic Indicators

Mortality rate of less than 5 years, 1990	80
Mortality rate of less than 5 years, 2012	31
Infant mortality rate (under 1 year), 1990	63
Infant mortality rate (under 1 year), 2012	27
Neonatal mortality rate 2012	18
Total population (thousands) 2012	32521.1
Annual number of births (thousands) 2012	738.7
Annual number of deaths under 5 years (thousands) 2012	
Maternal mortality rate, 2008-2012 *, declared	130
Maternal mortality in 2010, adjusted 100	23

Disparities - Rural and Urban

Birth registration (%) 2005-2012 *, urban	96.8
Birth registration (%) 2005-2012 *, rural	91.3
Births attended by skilled health personnel (%) 2008-2012 *, urban	92.1
Births attended by skilled health personnel (%) 2008-2012 *, rural	55
Prevalence of underweight children under 5 years (%) 2008-2012 *, urban	1.7
Prevalence of underweight children under 5 years (%) 2008-2012 *, rural	4.3
Prevalence of underweight children under 5 years (%) 2008-2012 *, proportion urban / rural	2.5
Use of improved sanitation facilities (%) 2010, Urban	83.1
Use of improved sanitation facilities (%) 2010, Rural	52
Use of improved sanitation facilities (%) 2010, Rural, proportion urban / rural	1.6

In Morocco, the decrease of mortality rates for children under five was due to a variety of vaccination campaigns, increased access to care for women, and an increase in skilled assistance during childbirth. It declined from 76 deaths in 1,000 births to 31 deaths per 1,000 births, which exceeds the objectives of the Millennium Goals.

As a representative of the Health Ministry and delegate of the Province of Khemisset I heard about the "Mobile Ultrasound Patrol Project" in October 2013 from Professor Melhouf of the CHU de Fès. He explained to me that two ladies were bringing a new technology into his hospital that could transmit images to a referring physician for a second opinion through a cell phone. The idea being that this would connect women in rural areas to better healthcare, even helping them to detect at-risk pregnancies more quickly. Their mission corresponded to the global purpose of the Ministry of Heath of Morocco in trying to reduce infant and maternal mortality in rural areas (MDGs 4 and 5.) I was curious to see if this project could really help mothers and children in our region avoid pregnancy and delivery complications.

The project also planned to demonstrate how a second opinion gotten via the web could happen within a very short timeframe – without needing to transfer the patient at all. Obviously, this could save money but overall it could save lives through a faster transfer of ultrasound exam results.

I am responsible for the health centers in the region of Khemisset and I was immediately interested in exploring this opportunity for my region. I wanted to be sure the project leaders could get a feeling of the real situation in rural Morocco so I showed them a few health houses. On the same day, we agreed that we would begin with health houses in three locations - Oulmes, Khemisset and Ribat el Kheir – where we would provide ultrasounds using portable devices for pregnant women. I was excited to start this project as quickly as possible and achieve its goals with the help of Dr. Bennani, Health Minister of Rabat, the support of local teams around the University Hospital of Fès and the public Hospital of Tiflet.

On our first stop of the early morning in Oulmes, the whole team was impressed to see that approximately thirty women were already waiting in front of the heath house. Some of them came with two or three children and had walked for an hour just to see their baby in a first ultrasound exam. The women and their families were very interested in the project and we were touched by their friendliness and openness to new technology. Relationships have been built up between the team in Oulmes and the families coming to the Center and we were very thankful to be able to offer them this experience.

As a side note - the equipment of the health house also left an impression. There is a great need to improve even just the basics:

- Heating
- Electricity in all rooms
- Medical levels in the delivery room
- Hygiene
- Reporting and documentation

I want to highlight that apart from the medical aspect for the patients who received examinations, the training aspect during this project was very helpful for the doctors and the midwives in those regions. During the caravan, specialists in OB/GYN educated the local staff about placenta previa (Dr. Guillaume Benoist - Caen) and different fetal malformations (Dr. Laurent Bidat – St German in Laye.)

Dr. Chrit – delegate of health – province de Khemisset

Also, delivering at home in these regions still remains very common. My colleagues and I are convinced that by making ultrasound available and affordable for all mothers during regular prenatal visits in "their" health house we could increase the number of deliveries in those environments - where there would be help from the local staff and midwives. But we are also aware that the local teams need to be consistently trained to improve their knowledge of new technologies.

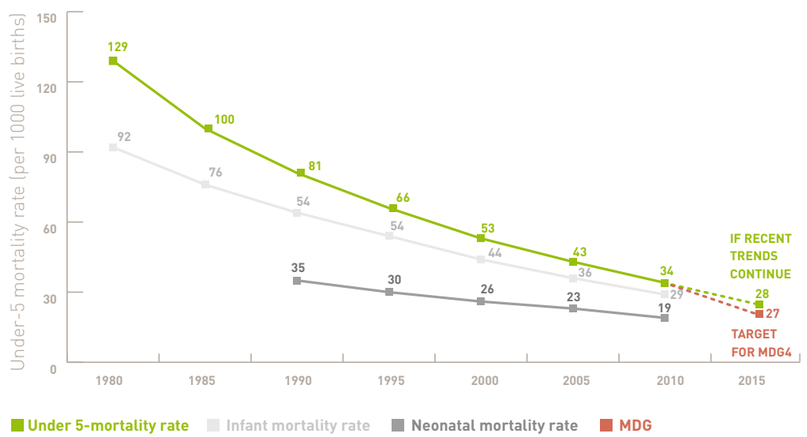
During the ten days the team was here in January and February of 2014, the caravan and the entire project were extremely interesting. During those days spent in Oulmes I could see how remote access to professional diagnosis could make a difference in medical care for these women and their families. They could benefit not only from an ultrasound scan but also from real prenatal diagnoses in order to avoid problems in their pregnancy. In my opinion this should be repeated in other regions.

With the local team in Oulmes, doctors from Tiflet and Khemisset and the help of Dr. Bidat, two hundred and forty women were seen within three days in three different exam rooms. There were even two babies safely delivered to mothers that we were able to scan in advance, to see if they would need special care. We detected twenty-five risk pregnancies and two mothers were transferred to local clinics for urgent surgery.

As a delegate of the Minister of Health, I would like to thank all participants from Trice, SonoSite, Qualcomm and the regional health offices as well as the Ministry who made this project possible. It really demonstrated that the use of new technology could make a significant change to healthcare in the rural areas of Morocco. It could help us to increase our health standards and save the lives of mothers and their babies.

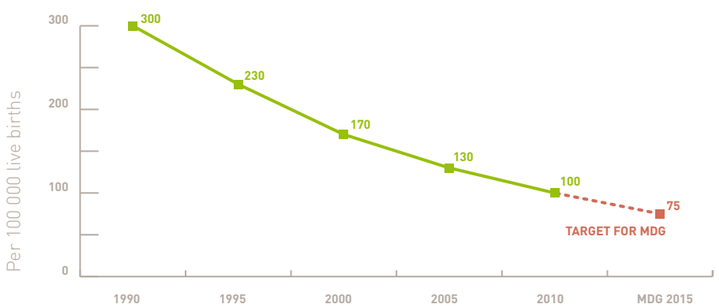
We achieved great results as a team and we are hopeful this is just the start of a long cooperation – THANKS !!

Trends in under -5 mortality 1990-2011 and extrapolation to 2015



SOURCE: United Nations Interagency group for child mortality estimation (IGME) - Levels and Trends in Child Mortality, Report 2012 - WHO/UNICEF/World Bank/UNDP and independent experts. These figures are computed by the UN agencies and are not necessarily the official statistics of the Member State, which may use alternative methods of estimations of mortality. All Member States have undergone an official country consultation on these stimations. [10]

Trends in maternal mortality reduction between1990-2010 and extrapolation to 2015



SOURCE: WHO, UNICEF, UNFPA and The World Bank estimates, Trends in maternal mortality: 1990-2010, published 2012.

Preventing Maternal Mortality[11]

Eight hundred women die every day from preventable causes related to pregnancy and childbirth, with 99% of deaths occurring in developing countries. The high numbers of maternal deaths reflect lack of access to quality health services and highlight the inequalities between rich and poor countries. More than half of these deaths occur in sub-Saharan Africa and almost one third occur in South Asia.

The ratio of maternal mortality in developing countries is 240 per 100,000 births versus 16 per 100,000 in developed countries. There are great disparities between countries, with a few countries having extremely high maternal mortality ratios of 1,000 or more per 100,000 live births. There are also differences within nations, between high and low income families, and those living in rural versus urban areas.

Women in developing countries have, on average, a higher number of pregnancies than women in developed countries and therefore, their lifetime risk of death due to pregnancy is consequently higher. There is also a higher risk of maternal mortality for girls under 15 years of age. The probability that a 15-year-old girl will eventually die from a maternal cause is 1 in 3,800 in developed countries, versus 1 in 150 in developing countries. In fact, complications in pregnancy and childbirth are the leading cause of death among adolescent girls in most developing nations[12].

In 2011, Morocco reported important achievements in coverage for mother and child healthcare services with 77% of pregnant women receiving prenatal care (62% in rural areas and 91% in urban areas). This is the highest percentage over the past 24 years, while its lowest percentage was just 25% in 1987[13]. However, there is still room for improvement in client-use and quality of antenatal care (ANC) services in Morocco.

Roadmap to Achieving MDGs 4 and 5 in Morocco

Maternal mortality is a priority for the Moroccan government and in 2008 the Ministry of Health (MOH) developed specific actions in The Moroccan National Acceleration Plan for 2008-12 to accelerate the reduction of maternal mortality.

The Moroccan National Acceleration Plan targets nine regions—home to 66% of the country's population—that currently have lower exposure to maternal and child health services due to difficulties accessing health services in remote areas, a shortage of trained health workers and low quality of services. It identifies key actions that will enhance the capacity of these regions to plan, implement, follow up and evaluate services for women and children. The plan is aimed at helping rural women benefit from local resources and is designed to increase a mother and child's access to high-quality services at clinics and hospitals.

"This plan is going to make a real difference for women and children living in areas of the country where health services are most in need of strengthening. It clearly sets out the actions that need to be taken to make new, life-saving services available and extend and improve existing ones."

Dr. Souteyrand, WHO Representative, Morocco

Under the Moroccan National Acceleration Plan, services have been made available at no charge, equipment and infrastructure will be upgraded, health workers will get more training on best practices, communities will be involved as an interface between the population and health services, and accountability mechanisms will be put in place at regional and local levels. Transportation systems will be improved so that pregnant women can travel safely from home to hospital, and those with complications will be able to receive specialized care for procedures such as caesarean sections.

"This plan is critical for Morocco to accelerate reductions in maternal and child deaths. With WHO's support, the Ministry of Health now has a roadmap to achieve MDGs 4 and 5."

- Dr. Abdelali Belghiti Alaoui, Secretary General of the Moroccan Ministry of Health

Moroccan Health Insurance, a combination of public and private healthcare systems

Since 2005, all Moroccan citizens have been required to be members of a basic medical plan, via their local region. All people are required to have access to a Medical Assistance plan. These plans are based on the principle of social welfare and national solidarity. It allows people who are not contributing to a Medical Assistance Plan to benefit from treatment dispensed in public medical centers as well as state-provided health services[14].

Elements of other, private insurance[15]:

- France and Morocco have also signed a bilateral Social Security agreement. Moroccans that are employed by a company based in France can partake in a French Social Security plan if the employer agrees to it. At the same time the employee pays into a Moroccan Social Security top-up plan.
- There are charges for additional private insurance regarding specific treatments for those contributing to a top-up plan.
- An insured can also chose to pay for private insurance and be eligible to go to any doctor in any clinic or hospital. Treatment is fully reimbursed depending on the terms of the insurance policy.
- The private sector is well developed in Morocco and is made up of primary care doctors, specialists, private clinics etc.
- Treatment is of better quality than in the public system but the prices are higher.

Morocco has a low doctor - patient ratio, numbers of physicians (0.5 per 1,000 people) and hospital beds (1.0 per 1,000 people) and poor access to water (82% of the population) and sanitation (75% of the population)[16].

The healthcare system includes 122 hospitals, 2,400 health centers, and 4 university clinics, but they are poorly maintained and lack adequate capacity to meet the demand for medical care. Only 24,000 beds are available for 6 million patients seeking care each year, including 3 million emergency cases. The health budget corresponds to 1.1 percent of gross domestic product and 5.5 percent of the central government budget[17].

In comparison[18]

	Number of Nurses /100,000 inhabitants	Number of Doctors /100,000 inhabitants
South Africa	393	74
United States	901	247
France	822	328
Morocco	90	50

What can be done?

While maternal mortality worldwide dropped by almost 50% between 1990 and 2010, there is still more work to be done. Plenty of healthcare solutions are available that can prevent most maternal deaths. Simply put, expectant mothers need access to prenatal and antenatal care during pregnancy, skilled care during childbirth, and proper care and support in the weeks after childbirth.

Most of the complications that result in maternal death develop during pregnancy. The major complications that account for 80% of all maternal deaths are: hemorrhage (severe bleeding, mostly bleeding after childbirth); infections (usually after childbirth); obstructed labor; hypertensive disorders in pregnancy (high blood pressure conditions such as pre-eclampsia and eclampsia); and abortions. The remainder are caused by, or associated with, diseases such as malaria and AIDS[19].

It is particularly important that skilled health professionals attend all births, as timely management and treatment of issues can mean the difference between life and death.

Even though Morocco has been able to reduce the rate of women dying during childbirth, the number still remains very high. In 2009, 112 women died per 100,000 live births (compared to 337 per 100,000 between 1985 and 1991[20]. In the Moroccan countryside, women are even more likely to die while giving birth, with 148 women dying per 100,000 live births, compared to 73 in urban areas[21].

The main causes of maternal death in Morocco are: hemorrhage (33%), followed by hypertensive disorders (18%), infection (8%) and uterine rupture (7%). These clearly fall into the category of preventable and treatable conditions that should not contribute to maternal mortality.

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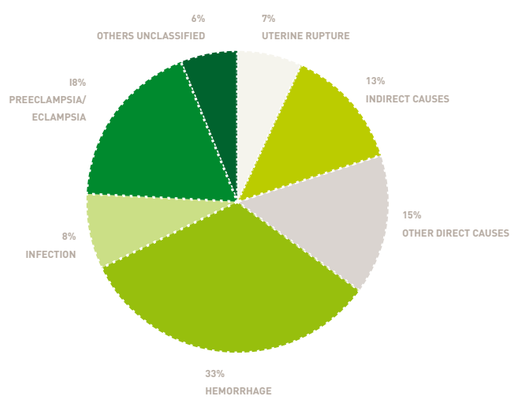


The Role of Ultrasound During Pregnancy

In a 2011 study called "The Role of Obstetric Ultrasound in Reducing Maternal and Perinatal Mortality", the WHO lists the most common causes of neonatal mortality as infections, birth asphyxia, birth injuries, preterm births, and birth defects.[23] It is worth noting that these mortality causes are conditions for which timely ultrasound imaging could be of immense help in early diagnosis and hence intervention, leading to the reduction of mortality rates among mothers and their babies.

Maternal mortality related to pregnancy is the leading cause of death in women of child-bearing age, and almost all maternal and perinatal deaths occur in the developing world. Introducing ultrasound technology to prenatal care can help identify pregnancies at risk of adverse outcomes and plan deliveries in hospital settings. Complications such as ectopic pregnancy, placenta previa, multiple pregnancy, fetal malposition and abnormal fetal growth are known to increase morbidity and mortality and can all be simply diagnosed by ultrasound. [24]

First trimester conditions detected by ultrasound imaging

In the first trimester, ectopic pregnancy and gestational trophoblastic diseases (GTDs) are the most common complications that can cause maternal mortality, due to the possibility of severe hemorrhage, shock or sepsis. Patients usually experience bleeding and/or pain but can also remain asymptomatic for a long period of time. Ultrasound imaging is extremely useful for obtaining accurate diagnosis for these first trimester conditions. It is therefore important to include early pregnancy pathology in every woman of reproductive age who experiences amenorrhea, abnormal bleeding and/or pain, using diagnostic ultrasound imaging in combination with beta human chorionic gonadotropin (Ð-HCG). This approach to medical care can potentially reduce maternal mortality rates.

In terms of perinatal mortality, the role of ultrasound imaging in detecting markers for chromosomal anomalies and structural defects in the fetus is very important and will enable early intervention or close monitoring. [25]

Ectopic pregnancy

Ectopic pregnancy accounts for 9% of all pregnancy-related deaths (Uzelac and Garmel, 2007). However, because of improved diagnostic capabilities, notably in ultrasound imaging, the incidence of mortality has relatively declined in the US and other developed countries since the 1970s, despite the increasing number of ectopic pregnancies (Lawson et al, 1988; Levine, 2000).

This implies that improving on the use of ultrasound imaging in developing countries could also improve survival rates for those at risk for ectopic gestation.

Induced Abortion and miscarriage

Unsafe abortion is known to account for 13% of maternal mortality[26]. Regardless of whether an abortion is spontaneous or induced, subsequent events and the care received determine whether the abortion is safe or unsafe. If an incomplete abortion is not appropriately treated, it can lead to hemorrhage, shock, sepsis and death. Ultrasound imaging is useful for obtaining definitive diagnosis, as the symptoms of incomplete abortion and ectopic pregnancy may be similar. Moreover if a miscarriage is assumed, or termination of pregnancy is carried out without an ultrasound, one may not know the cause of subsequent complaints of bleeding and pain. Additionally, early ultrasound imaging may prevent uterine perforation, which can occur during evacuation of an incomplete abortion or termination of pregnancy as a result of retroverted/retroflexed uterus. Ultrasound is also useful in determining which pregnancies are viable and which are most likely to miscarry[27].

Gestational age estimation

Gestational age (GA) has emerged as one of the most important predictors of perinatal mortality. [28] The outcome of pregnancy is more closely related to GA as determined by ultrasound imaging. Accurate GA enables future detection of intrauterine growth restriction (IUGR), large for gestational age (LGA), and is also essential in decision making for delivery or conditions such as premature rupture of membrane (PROM), postdates, placenta previa, and hypertensive disorders.

Second trimester conditions detected by ultrasound imaging

Second trimester ultrasound imaging is typically performed between 18 and 24 weeks of gestation. Ultrasound imaging is performed to evaluate fetal and maternal structures for abnormalities that could lead to maternal and/or perinatal mortality. The structures evaluated are fetal anatomy, fetal biometry, amniotic fluid volume, placenta, maternal cervix and Doppler velocimetry of uterine, and umbilical arteries. The purpose of second trimester ultrasound imaging is to identify findings associated with fetal chromosomal abnormalities, pre-term delivery, IUGR, and pre-eclampsia.

Pre-eclampsia and intrauterine growth restrictions remain the two most common causes of maternal and neonatal death, and should be detected as early as possible. Early knowledge of pre-eclampsia and intrauterine growth restriction by ultrasound imaging allows healthcare workers to provide appropriate antenatal surveillance and therapy in an effort to improve pregnancy outcomes. It must be pointed out, however, that prediction of these conditions in the second trimester is only possible if accurate dating from either early ultrasound examination or known conception dates has been previously established[29].

Sustainability of ultrasound imaging for the developing world

The WHO recommends dissemination of ultrasound to developing nations during the second phase of its earlier basic radiology system initiative. [30] Ultrasound was described as a "sustainable technology" for developing and low-resource countries, due to its relatively low cost of purchase, maintenance, and supplies; portability; and durability compared with all other imaging modalities.[31] Currently, the increasing availability of affordable and smaller ultrasound scanners is a clear indication of the sustainability of ultrasound for the developing world and its potential role in reducing maternal and perinatal mortality.[32] A market survey conducted by Harris and Mark, 2009 (unpublished)[33] revealed that a new ultrasound machine could cost as little as $5000, and can be used for basic obstetric assessment such as gestational age, fetal viability, placental position, and may even be used for fetal anatomical survey. Further evaluation with more sophisticated and relatively expensive machines can then be arranged for selected cases with suspected anomalies, as a form of 'level 2' or 'level 3' scanning conducted by an advanced practitioner or specialist. Moreover, the practice of donating slightly used but good quality machines continues to be helpful and should be encouraged.

The lack of adequately trained physicians and sonographers, and the limited means of equipment maintenance in developing countries is a major challenge.[34] Even though some developed countries around the world make a concerted effort to provide education, it continues to be provided in a random fashion and has never been able to keep up with the need for adequate training for physicians and sonographers. One proposal of using a low cost system for training ultrasound imaging techniques was via the use of a PC platform that uses interface components from the Nintendo Wii games console (as a simulator) to aid remote mentoring by experienced ultrasound professionals. The proposers cited their experience using this technique in Ghana.[35]

Another recommendation was to incorporate a diploma in clinical ultrasound for medical graduates of local universities.[36] The use of existing allied health professionals such as nurses or midwives or radiographers who have received additional training in ultrasound is valuable in some developed countries, and may be cost-effective in developing countries. A new model in developing countries is the creation of Bachelor degree programs in sonography at existing universities. Graduates of these university sonography programs may help ease the pressure on doctors in developing countries.

It is the belief of the authors that a three-pronged approach must be utilized for the sustainability of ultrasound in developing countries: first, the development of a new career path through the university setting for sonographers; second, the creation of long-term comprehensive sonography education programs for physicians; and third, the involvement of government agencies and institutions for regulatory policy setting. A creative approach that serves the unique situations of developing countries and addresses the need for trained ultrasound operators would be highly beneficial.[37]

The potential of ultrasound and mobility in Morocco

Most of the world's maternal deaths (99%) occur in developing countries, where ultrasound imaging is currently underutilized. Financial constraints are cited as the main reason for this underutilization. It is expected that limited resource environments could benefit from prudent application of ultrasound imaging, which is a relatively affordable and safe imaging modality. As technology has made this modality so affordable and widely available, ultrasound application could easily help improve survival rates. Ultrasound is a non-invasive and safe tool that can aid in the diagnosis of most potentially dangerous conditions, prevent the effects of these complications and in some cases guide in treatment. Thus wider use of ultrasound is advocated in obstetric practice. It is important for every medical doctor in the obstetric unit and midwives to be trained in basic use of ultrasound. The need for advanced practice training for specialist obstetricians as sonologists, and professional sonographers as advanced ultrasound practitioners are recommended for the future in developing countries as currently practiced in some developed countries. [38]

According to Ericsson's Mobility Report from Q3 2013, 6.6 billion people worldwide have a mobile subscription. There were 42 million mobile subscriptions sold in Morocco 2013, making the mobile penetration rate 130% for a population of 32 million people. [39]

In Morocco, 3.35 million people owned a smartphone in 2013. This equates to 8.3% of the mobile users and is trending with global growth, which increases 50% each year. Mobile broadband subscriptions exceeded 2 billion in 2013, globally, and are predicted to grow four times by 2019, reaching 8 billion worldwide. [40] By the end of 2019, around 90% of the world's population will have the opportunity to access the Internet using WCDMA/HSPA networks and 65% of the world's population will be covered by LTE in 2019. This means that the opportunity to access medical images on a personal smartphone will be a reality for the majority of the world's population by 2019.[41]

Morocco has two cellular carriers that provide 3G mobile services. The coverage in outer villages where the trial was executed had varying network quality. The solution also works with 2 and 2.5G networks, albeit with slower data upload times.

Medthodology and execution

The scrope ot the project

The Mobile Ultrasound Patrol Project was designed to illustrate how advanced wireless technologies can replace the existing traditional means of transportation for medical images in rural settings.

The Project scope was purely technical. It had no clinical claims and it was not in any way meant to provide diagnostic research data.

The purpose of the project was to determine if, with advanced wireless technologies, it is possible to:

- Obtain a diagnosis faster and more cost efficiently (versus fax, mail, or transporting them by individual drivers)
- Provide images of diagnostic quality after transmission via the wireless technology

The assumption is that if a particular combination of technologies can transfer medical data at the desired quality level more quickly and less expensively than other methods, then making this technology available to healthcare providers would result in additional and improved care, ultimately reducing maternal and child deaths.

Technology used in the Trial

Part of the mission of the Mobile Ultrasound Patrol project was to evaluate the technology used in order to create a packaged solution that could perform in rural and underserved areas.

Several guidelines were established:

- Utilize as few components as possible, so that the solution was manageable. This included eliminating the need for a workstation to capture images.
- Prioritize portability so that a device can be held in one hand.
- Minimize energy usage since the technology will be used in areas where a reliable power source is limited or unavailable.
- Obtain consistent connectivity, through 3G/4G connectivity, so that healthcare workers could transmit images from anywhere.

113 Examinations in 8 weeks

3 rural locations

3 reading physicians

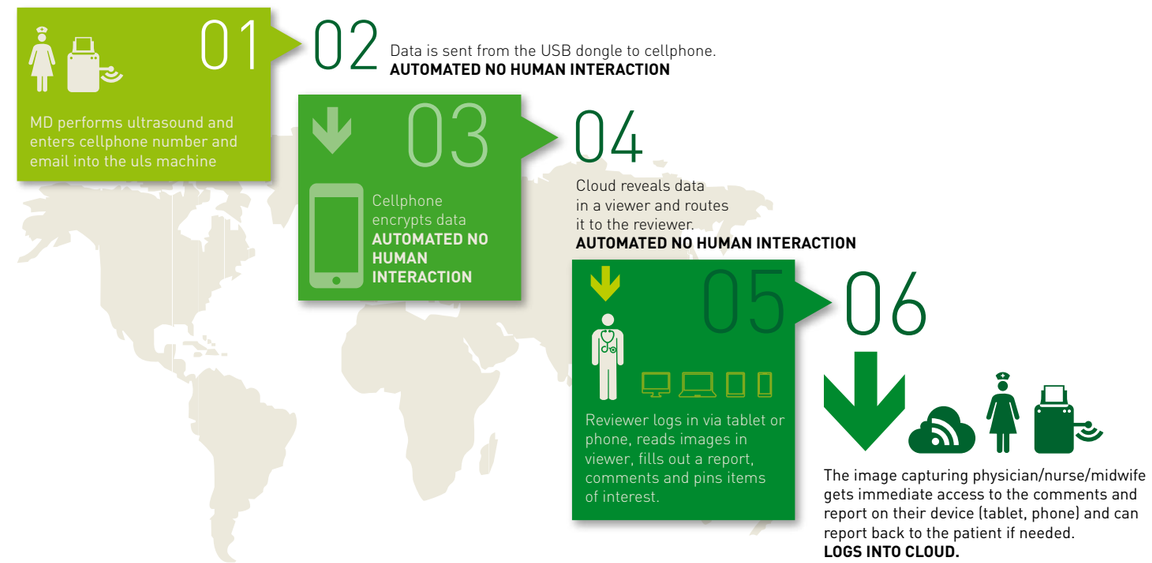
46 patients flagged for second opinion

24 high-risk pregnancies

3,108 images transferred through wireless technology

Average transfer time
– less than one minute

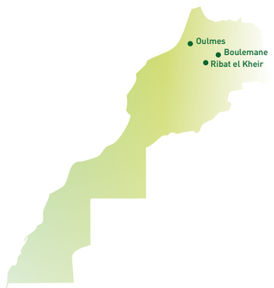
Workflow



The Mobile Ultrasound Patrol project used a simple set up:

1. Images were captured with a portable ultrasound called the M-turbo from SonoSite.
2. The images were wirelessly transmitted via WiFi through a dongle to a Qualcomm-enabled wireless device, in this case a Sony Expedia cellphone or tablet with a pre-installed DICOM encryption application.
3. The images were transmitted from the mobile device via the mobile network to a cloud-based image management platform provided by Trice Imaging Inc.
4. The images were made available on a secure Internet landing zone. A link to the images was automatically routed to the reviewing physician via an encrypted email.
5. The reviewing physician logged into the system on a Qualcomm-enabled, Sony phablet (phone – tablet) to review the images and complete a report.
6. In the image management solution, the physicians on both ends could review the images on a viewer, and collaborate, provide comments and pinpoint areas of interest on the images. The data was transmitted in its original form so no degradation of image quality occurred. The users could choose to send anonymized data to include patient identifiers.

It is very important to point out that the solution works with any ultrasound machine that has the DICOM standard, and can be connected to the network either via Ethernet cable or via a mobile connection. Furthermore, it works with any cellphone that can receive a text and email and open a link as well as any reviewing device that has a browser. When using fixed Internet some of the mobility aspect is lost, limiting use to places with high-speed fixed Internet. Using advanced wireless technologies allows for a mobile examination situation where both the image capturer and the reviewer can provide care where ever they are. The device can be moved to a bed side in the labor and delivery room, to a home visit, a scene of an accident, or in a moving vehicle. The reviewer can literally have access to review from their pocket.



The Methodology

The project involved a combination of gathering primary data regarding time and cost for transmissions acquired by the mobile technology used in the trial and comparing it with secondary data regarding time and money collected through researching official government documents and interviewing local representatives of the government and healthcare providers to judge the current method's abilities. The image quality was evaluated separately from both a technical and medical perspective using the industry standard rating protocol described below.

Time measurement protocol

Measurements of the time it took to transport/deliver the studies from image capture to review and diagnosis were captured to compare the technology used in trial with standard methods already being used in the region e.g. car, Fedex and couriers, etc.

Cost Comparison protocol

The project compared the cost between the mobile technology used in the trial and traditional methods e.g. FedEx, courier, printout, etc.

Image quality protocol

The trial determined if the images shared via wireless technology had similar diagnostic quality to those shared via traditional methods.

The eight-week field work phase of the project took place in January and February 2014, and a total of 113 ultrasound studies were conducted. However there is no difference in results for the 113 and 575 studies. All studies were collected by the same means and method. The data collected was then compared with other data to create parity between the wireless technology used in the trial, and the traditional way images are analyzed.

Execution, data collection, comparison and analysis

The credentials of the volunteering physicians were verified and each participated in ultrasound training before the trial commenced to ensure that they had sufficient skills in ultrasound image capturing. This training was conducted in December 2013 by Dr. Guillaume Benoit – Centre Hospitalier Universitaire (CHU) Caen.

Various training sessions were provided to midwives and doctors during the trial period by Prof. Melhouf and Dr. Bidat. All participants were trained on the equipment used during the study and the different measurements used to ensure that they matched medical protocol.

Three villages in rural Morocco, Oulmes, Boulemane and Ribat el Kheir were selected as project locations. Eight physicians agreed to participate in the trial, performing the examinations, acquiring and transmitting the images. Five reading physicians were selected in Casablanca, Fez and Paris, France.

Reviewing clinics

- Dr. Akiki – Radiologie Casablanca
- Prof. Herlicoviez – CHU de Caen
- Dr. Guillaume Benoist – CHU de Caen
- Dr. Laurent Bidat – Private clinic in Paris, France

Image capture and first diagnosis

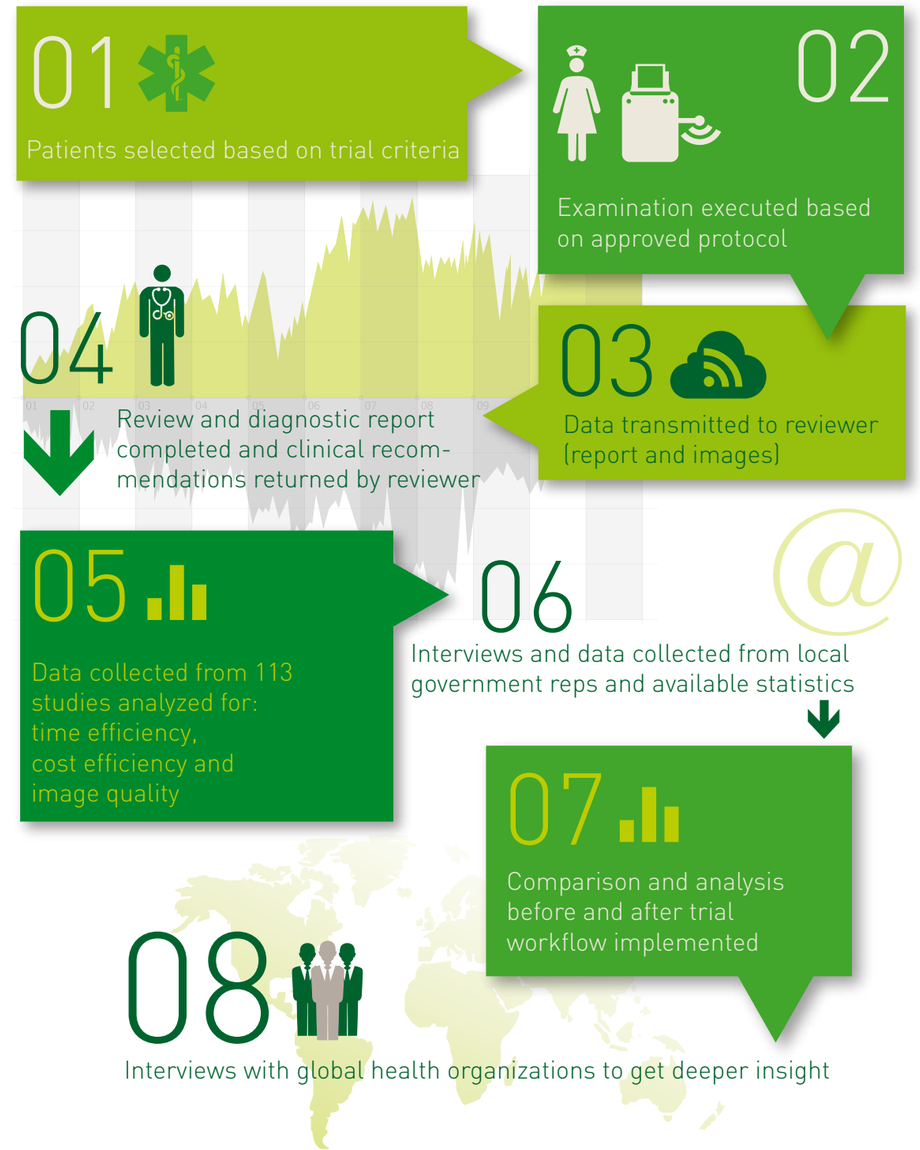
- Prof. Mellhouf –CHU Fès
- Prof Hekmat – CHU Fès
- Dr. Hichham Benyoussef – Tiflet Hospital

The study followed a specified examination protocol. Each patient was asked to take part in the project and was duly informed about the procedure. All studies were automatically anonymous in the software solution so there was no traceability in terms of patient identifiers. However, all participants gave verbal consent. No patients under the age of 18 were allowed to participate in the project.

The ultrasound machines were connected to Trice Imaging's Cloud PACS solution through the mobile network via a DICOM encryption application on a Qualcomm enabled, Android cellphone. The ultrasound machines were configured to send the images to the solution automatically during the scan. A standard procedure ultrasound examination was performed. After the completed examination, the sonographer decided which of the participating clinics should receive the study. The selected reading physician received a secure link to the examination and communicated back to the performing sonographer. To what location to send the study for review was selected by the sonographer randomly.

After the studies were collected and reviewed, the trial was complete. All transmission times were subtracted from the imaging platform used and an average transmission time was calculated. The response time was also calculated and divided in to three areas: less than 24 hours, less than 48 hours, more than 48 hours. The image quality was determined by having independent users rate the images according to the industry standard scale: excellent, good/acceptable, and insufficient for technical and medical purpose.

After all of the primary data was collected and analyzed, health representatives from the Moroccan government were interviewed to collect the standard data to which the new data would be compared. The data collected through these interviews were then tabulated and extrapolated with official healthcare statistics from the region and Morocco in general. For example, the cost to transport a patient multiplied by the number of patients that need transportation in Morocco last year was compared to the cost of transmitting the ultrasound studies for a diagnostic review for the same number of patients.



Carla, Mohamed her son and her mother-in-law – Oulmes

Isn't it amazing having people from all over the globe here in Oulmes helping each other!!

I came to Oulmes because the first child of my husband's cousin was delivered in the health house. The mother of this baby was so excited and told me to come here the day before. She said there were great people there who were helping in the health house. I actually met a staff member who helped to deliver the baby and promised to come back again the next day.

I used to live in California in a glamorous world and was traveling quite a lot, as I grew up in a multicultural family. With a girlfriend I once traveled to Rabat and spent some time there and I fell in love in Morocco. A few months later, already back in the United States, I found out I was pregnant and decided I wanted to be near my husband. So I left California behind and stepped into a new adventure, far from my habits and far from my usual lifestyle.

Even if the living standard is so different from the USA, deep in my heart I would say that Oulmes, the people here and especially my husband's family, showed me the value of gratitude and attention to each other. It is a great place to raise children, especially out in the countryside.

I was, however, anxious when it came time to deliver my son Mohamed here. He was premature and I have hypertension. I was afraid of having my baby in a health house as I did not know what kind of health facilities and care I'd find there. So I decided to deliver in another facility. If I would have known that due to new technology we could get access to healthcare and reliable diagnostics like in the USA, I would have been happy to have my child here and I certainly can speak for many women who have the same concerns in all of those rural areas in Morocco.

Keep in touch and let us know when you come back so we can continue to exchange ideas and help each other.

Quality

The quality of the trial was monitored throughout the process. A few distinct measures were undertaken to guarantee the validity of the data and secure overall project quality.

Validating Entities

- One of the maternal fetal medicine industry's most respected physicians, Dr. Larry Platt, acted as advisor for quality assurance
- Representatives from the local Moroccan government and Ministry of Health were very engaged in both the design of the process and the execution
- The examination protocol was developed by the participants and compliant with local recommendations
- All comparative local data was collected from official Moroccan sources including statistical reports from the government and information provided by official representatives of the health Ministry

Validating Participating Scanners

- All credentials for the participating physicians were validated by the project team
- All participants participated in the trial ultrasound training before starting the project

Validating Data Collection

- All data was duly encrypted to ensure patient data security
- All personal identifiers were removed from the patient data sets
- All data was collected under the surveillance of the investigators
- No diagnostic work was executed within the project, but support systems were prepared to support any uncovered need for diagnostic work

Results

Over the course of two months (January and February of 2014) 113 ultrasound studies were collected in three small villages (Oulmes, Ribat el Kheir, Boulemane) in rural Morocco. The purpose was to compare: the cost, time gap to diagnostic expertise and image quality between a new digital imaging technology and the normal, local ways of execution. For each variable, (time, cost and quality) we have compared two scenarios which include the way the procedure is normally done and how it was executed during the project.

Time efficiency

Normally, it takes approximately two hours for a pregnant woman to reach a health house in rural Morocco.[42] Once she arrives she receives an examination and medical care, the cost of which is covered by the government. A generalist or a midwife working in this location performs these exams. The patient needs further analysis from a referring physician approximately 25% of the time.

In a case where a second opinion is needed, or the woman has to be transported for follow-up surgery to a nearby hospital, transport is organized by the health house and, for the most part, the government covers the transportation costs. If an ambulance were to be available in the health house it would take an average of 2 to 4 hours to get to the next hospital, otherwise it can take up to 4 weeks before a pregnant woman can find transportation (usually from a family member) for a follow-up visit.

A second opinion can also be acquired if results are sent to the nearest hospital that is related to the health house. Sending materials by delivery service e.g. FedEx is not a possibility in most of those rural areas so traditional post is the only way to send a report, which could take a minimum of 3 days one-way.[43]

Using the traditional means, it takes an average of 2 weeks for a patient to receive a second opinion from a referring physician.

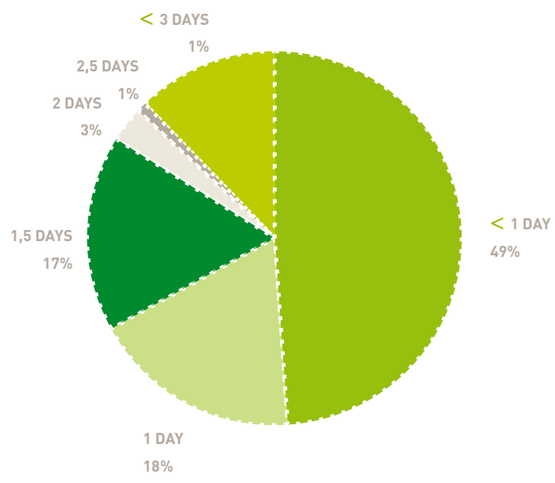
During the trial, 113 were examined under IRB and all studies were sent through a Cloud imaging platform on mobile devices for a second opinion. The average transmission time from the examination to the platform was less than one minute for all 113 examinations.

The ultrasound images captured by the midwife or generalist were transferred through the Cloud to the referring physician who got a message on his/her mobile phone via e-mail. With a personal access code he/she connected to a secure link on the imaging platform through an encryption application on a wireless device with Internet access. The referring physician then provided a professional diagnosis within minutes.

It is remarkable that the responding time from the referring physicians back to the senders was less than 24 hours for 49% of all studies sent. 39% of the studies got a response within 48 hours and only 12% needed more than 72.

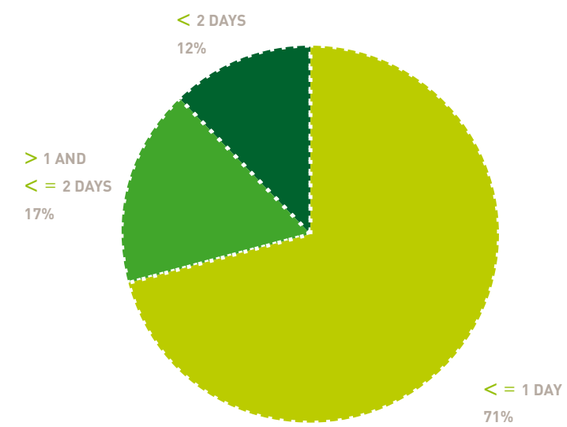
The Mobile Ultrasound Patrol Project shows that using advanced wireless technologies and a Cloud-based system can have a significant impact on medical care. It is more time-efficient for reading images and could quickly connect a health house to a regional hospital or a University hospital. A pregnant woman could follow-up and obtain a second opinion immediately, if needed, instead of being transferred to a hospital or waiting for results in the mail. These technologies not only help the (image-capturing) healthcare worker to make appropriate decisions but will save time for all physicians in health houses. In addition, it will save time for the patient in cases of emergency. Most importantly, it will expose any serious complications and educate and empower expectant mothers to take action.

Response time via the online platform



Note that this project was conducted solely for technical purposes but in order to bring context to the data reported some clinical information is offered. Out of the 113 patients 24 cases were diagnosed as risk pregnancies by the image capturer due to the ultrasound examination or patient history. For 17 patients (71%) out of those cases the responding time was less than 24 hours. For the remaining 7 patients (29%), more than 24 hours were needed.

Response time for risk cases



Using advanced wireless technologies to send medical images through the web decreases, without any doubt, the time to diagnostic expertise. The time it takes to get a second opinion using traditional procedures in this region could decrease from an average of 2 weeks to an average of 1 ½ days by using advanced wireless technologies.

70% of the 113 examinations were transferred within 1 minute to the wireless platform and from there to the referring physician for a second opinion. Another 26% of the transmitted examinations needed fewer than 2 minutes of transfer time. The other 4% of the images were transferred in between 2 – 5 minutes due to a delay in 3G coverage at the moment of transmission.

The technology used in this project alerts the reviewer and ensures the studies are available for review in a matter of seconds. Please note, during this project image reviewers were not instructed to be "on call." They reviewed the studies when they had time or at the end of each business day. If the project had set response criteria to be met by the reviewers this number may have been different.

	NORMAL SCENARIO	PROJECT SCENARIO
Transportation of data	2 days to 2 weeks	< 1 minute
Transportation of patient for second ultrasound	2 hours	n/a
Time for diagnostic response	2 days to 2 weeks	< 24 hours

Cost efficiency

Normally, to get an examination during pregnancy, Moroccan women will go to their nearest health house. Most of these locations do not have access to ultrasound, so pregnant women are sent for an ultrasound at an adequate location, most likely the next regional clinic. Most of the time the transport is done by hospital ambulance, if there is not one available in the health house. Women living in rural areas sometimes have to travel up to 50 kilometers for care and it is not rare for pregnant women who are ready to deliver to walk up to ten kilometers to access a road or closest health center or regional hospital. [44]

Once a pregnant woman arrives at the health house the government covers the costs for medical care and transport, if necessary, to the next regional hospital for a second opinion or urgent surgery. For the Moroccan government, the average cost of this transport by ambulance is $40 USD. The cost for additional ultrasound examinations is about $40 USD each. [45]

Using mobile technology dramatically decreases those costs as image management solutions allow digital transmission of images to a referring physician. The Mobile Ultrasound Patrol Project used Sony phones and phablets with a Qualcomm Snapdragon™ processor in order to transfer and receive images, including comments, to referring physicians. The cost for this transfer is approximately $2 USD for each dataset regardless of how many interactions take place between the image-capturing healthcare provider and the reading physician.

Out of the 113 examinations performed during the project, 46 patients were recommended to have a follow-up scan or a transfer of the patient for a second opinion to another location. The costs to transport these patients to the next adequate location would be $1,840 USD, which is funded by the Moroccan Ministry of Health. When the Trice image sharing technology is used, studies can be transmitted electronically, eliminating the cost of an extra ultrasound examination. The comparative cost to serve the 46 patients requiring follow-up would be just $92 USD and is infinitely faster and more convenient for the patient.

Medical image quality

The definition of quality has two perspectives according to the French Comité technique d'échographie foetle (CTE) which apply to Morocco: Technical, Medical

Technical perspective

The number of healthcare facilities in Morocco has increased to over 26,000 (1,938 health houses). 73% are in rural areas serving 13,467,000 inhabitants (41% of the population) and there are more than 20,000 doctors in Morocco. [46]

However, hospital spaces are still limited compared to the size of the population. Coverage of rural areas remains particularly weak, with some health centers closing due to lack of staff, equipment or medical supplies. Furthermore, the technical standard in these rural facilities remains behind the average and varies greatly from region to region. [47]

While medical equipment may be available due to support from international organizations, the local staff may not be properly trained on it, rendering it useless. Primary care in the health houses is mostly provided by nurses or midwives who, in Morocco, are not trained in ultrasound. [48]

In cases when an ultrasound device is available, the images are printed on thermo print paper as well as stored locally on the device. A hand written report is given to the patient. The equipment, on its own, does not allow exporting of images or sending via e-mail to any other physician for a second opinion. To reach a referring physician in another location, images are photocopied and, mostly, sent by regular post. This procedure causes a significant loss of image quality and does not correspond to medical standards. [49]

From a medical perspective and due to the actual technical requirements and equipment, 80% of the images taken in health houses before before the training could not be used for professional diagnosis.[50] In the project, the scans were reviewed and validated after transmission to the platform using the following guidelines:

a) from a technical perspective:

the quality was : excellent/average/bad/insufficient images good enough for medical diagnosis: yes/no

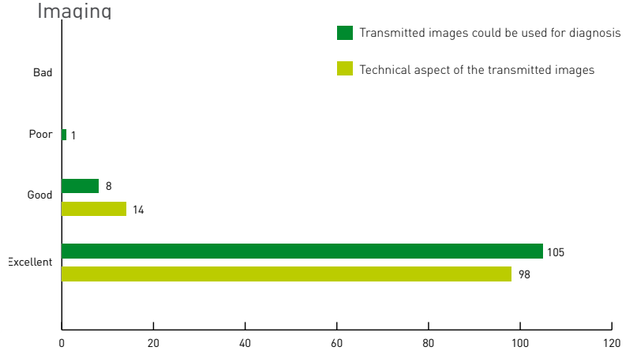
b) from a medical perspective :

the quality was : excellent/average/bad/insufficient images good enough for medical diagnosis: yes/no

The reviewer checked for brightness/contrast/focal position/frequency selection/tissue harmonics, and if the defined measurements had been taken and measured correctly.

The ultrasound devices used during the Mobile Ultrasound Patrol Project were capable of transferring images directly to the imaging management platform via encryption software (installed on a wireless device, in accordance with the international DICOM standard) without any loss of quality.

Technical aspect of transmitted images trough Trice Imaging



All 113 studies were sent to be evaluated on image quality. 86% of the images collected were considered "excellent" and 92% could be used for professional diagnosis.

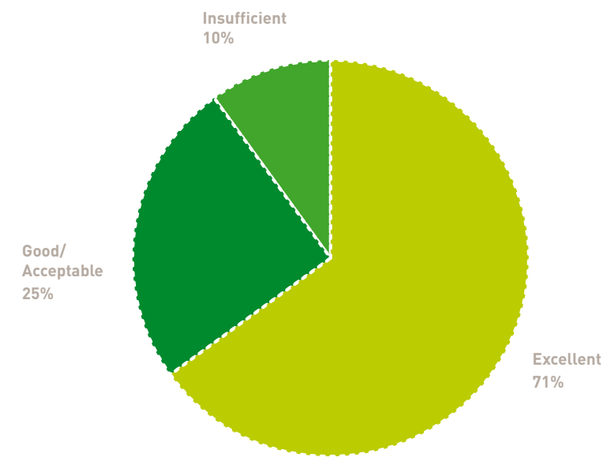
Medical perspective on image quality

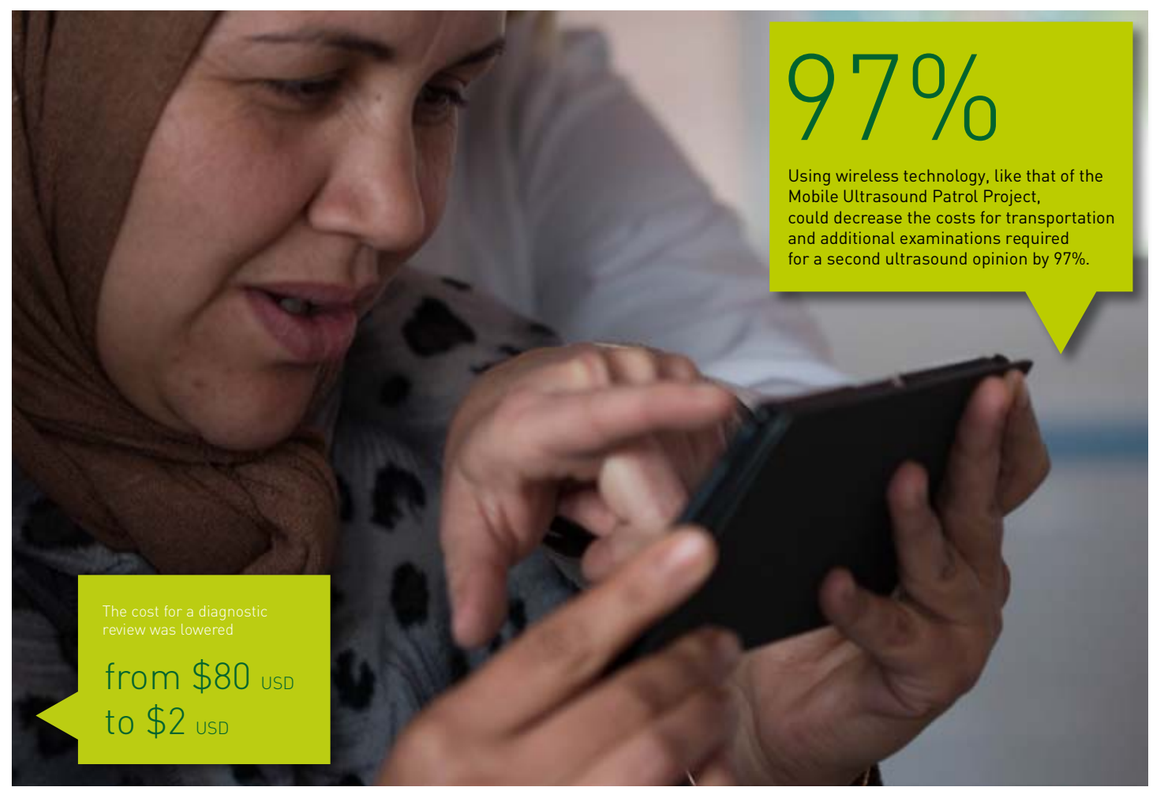
Morocco is one of 57 countries suffering from a severe lack of healthcare professionals and remains extremely vulnerable to their exodus to other countries. The lack of resources is exacerbated by unequal allocation of human health professionals between rural and urban areas and within the different regions of the country. With the current shortage there is virtually no unemployment for healthcare professionals, particularly specialists, general practitioners and nursing staff. [51]

In this context, the human resources strategy of the Ministry of Health is based on education and training, both initial and ongoing, in order to respond to the urgent need for healthcare professionals. From a medical perspective the Minister reports that it is important that the staff in facilities in rural areas constantly improve their knowledge through training and usage of new technology. [52]

There was a significant improvement in image capture in the health houses when comparing the Mobile Ultrasound Patrol Project to the studies performed during the training in Rabat in December 2013. Of the 113 examinations performed under IRB, 74 (65%) were rated "excellent," 29 (25%) were rated "good/acceptable" and 8 (8%) were rated "insufficient for technical or medical use."

Medical aspect of the transmitted trial images





Afterword

The results of The Mobile Ultrasound Project speak for themselves. But what do they actually reveal and what kind of questions do they raise for the future? In this segment of the report we will share thoughts and concerns of our own as well as insights from interviews we conducted with leading global health organizations. What you read here lacks primary data, it was not part of the project scope but is, nevertheless, quite important.

What does this project really tell us?

World health organizations take a stand for access to high quality of care during pregnancy and delivery as a human right. Access to ultrasound examinations is equally important and we believe that having access to a clinically trained person, in this case a maternal fetal medicine specialist, for high quality diagnosis is necessary to ensure the safety of both the mother and the child.

The WHO Constitution enshrines the highest attainable standard of health as a fundamental right of every human being. The right to health includes access to timely, acceptable, and affordable healthcare of appropriate quality. [53]

The United Nations further defines the right to health in Article 12 of the 1966 International Covenant on Economic, Social and Cultural Rights, which states "the right to the highest attainable standard of health" [54]

Patient rights in healthcare delivery include: the right to privacy, information, life, and quality care, as well as freedom from discrimination, torture, and cruel, inhumane, or degrading treatment.

ISUOG, the International Society of Ultrasound in Obstetrics and Gynecology's Outreach Program's vision is that every woman in the world will one day have access to an ultrasound scan and that every scan provider will be competent to diagnose major gynecological or pregnancy complications. In this way, ultrasound may play a part in reducing maternal and perinatal mortality. [55]

The United Nation's Population Fund's (UNFPA) role in this ecosystem is foremost as a catalyst for progress. Working with governments and through partnerships with other UN agencies, civil society and the private sector, UNFPA is the lead UN agency for delivering a world where every pregnancy is wanted, every birth is safe, and every young person's potential is fulfilled. Its network of regional and sub-regional offices provides technical expertise, drives innovative programs, including new technology, and coordinates the efforts of its country offices that work on the front lines of development, to improve the quality of care on a global scale. UNFPA believes in the power of technology. "We often talk about the great power of technology to transform and even save the lives of women and girls. This is a very good example of that power," said Erin Anastasi, Technical Specialist and Doctor of Public Health at UNFPA.

This projected also tells us that you could potentially bridge the divide between rich and poor, giving everyone access to the same healthcare privileges.

The Mobile Ultrasound Patrol Project shows us that new technology could potentially resolve one of the significant scarcities attributing to the issues: the lack of access to professional caregivers and physicians. We witnessed how untrained people excelled with the trial's tools in a very short time and that the reading physicians were content with what they received. This opens up new opportunities, by showing us that, with the right training, community workers, midwives and nurses can perform high quality ultrasound. We understand that this is a huge debate and moral dilemma in the industry of global health. UNFPA, and others, discussed a strategy (or trend) called ""task shifting." Erin Anastasi at UNFPA shared a story about research whereby non-physician clinicians (NPCs) were trained to execute essential, life-saving surgery such as a C-section. If that is possible, ultrasound scanning should be something that could be easily mastered by a community worker, for example.

Mariana Widmer from the World Health Organization (WHO) in Geneva is convinced that this Mobile Ultrasound Patrol Project demonstrates that it is possible to improve the diagnostic capacity of rural district hospitals in remote areas by using a clinician/midwife-performed, hand-carried, bedside ultrasound. In 1998, the WHO established standards in ultrasound training and recommended that an appropriate curriculum be adopted for the training of practitioners in the use of diagnostic ultrasound. However, training health professionals in ultrasound imaging is complex and takes considerable time. The possibility of sending images to a referral center would permit general health practitioners to perform ultrasound measurements without special training in ultrasound and allow patients to have an assessment done by an expert in the field.

What would be possible if there were access to mobile ultrasound all over the world? What kind of results could we see?

What would be possible with remote imaging diagnostics in a country like South Sudan where there are 120 physicians serving a 9,000,000 population and where 1 in 28 women die from giving birth? How many lives could be saved? Could the needle be moved? Could it go from 1 in 28 dying to 1 in 29 or better? What could be possible? [56]

How many midwives could be trained or how many doctors could be hired if millions of dollars were saved on transportation of patients?

Could there, in fact, be a link between access to the technology that provides access to care and the outcome of the MDGs? Comments and experiences from the WHO indicate that

Dr. Katof – Médecin hors garde
- S. Allal Bahraoui

The health center I oversee is in S. Allal Bahroui, in a small city near to Khemisset, but I had the pleasure of participating in a few days of the trial in Oulmes, a rural city in the mountains with 66,931 inhabitants. There, the percentage of women who have no regular ultrasound exams during their pregnancy remains very high.

I was interested to see what was going to happen because the word that an external team was coming to Oulmes to provide mothers the opportunity to see their babies was spreading there like wildfire. More and more women continued to come on the first day and we even had to tell them to come back the next day – when they came back with other women and their families!

Luckily, we were able to help all of those women. They each got an exam and a prenatal diagnosis with the help of physicians who gave us their opinion through the wireless technology. We found a lot of high-risk pregnancies and were able to avoid unnecessary travel for those pregnant women.

The highlights during those days:

- The time the team spent all together in the Berber house sitting around a fire to heat up after a long and cold day and talking about our experiences and impressions of what had happened

- The delivery of a baby to a young woman who came to us in pain. We scanned her and recognized that she was ready to deliver and that it would likely be difficult. We placed the mother in the so-called "delivery room" next to us. I asked Verena, our youngest team member, if she would like to assist me and she did. As a small team, we did our first delivery in this health house in Oulmes and saw, after a few intense and very emotional moments, a happy mother taking her baby in her arms. Verena and I were very touched to be able to be part of those unique moments. We still have contact with the families of the newborn and will keep this experience in our hearts.

I am still using the portable ultrasound device I received during the project in the health Center where I'm working, in S.Allal Bahraoui. I transfer the images through the Web to review them and to send them for a second opinion or to share them with other colleagues. Since I gained the opportunity to provide ultrasound to my patients there has been a significant increase of women coming to our Health center in order to get follow-up visits during their pregnancy. But, they are also coming for the confirmation of a pregnancy as soon as they have any inkling. Patients and their entire families are interested in this new opportunity to see their fetus and to prepare for delivery. I use the regular visits to give the women and their families further information about nutrition, family planning and other important aspects of good healthcare.

As a physician of a Health center I would never want to be without the ability to do ultrasounds. I am convinced that in the long-term this will help us to increase delivery in our facilities instead of having mothers giving birth at home. I am excited to be able to provide all kinds of healthcare in our facilities.

ultrasound is a valuable tool in all trimesters of pregnancy and plays an important role in early identification of at-risk pregnancies. Using this new technology would permit faster diagnoses of certain types of diseases or complications (ectopic pregnancies, intrauterine growth retardation, etc.) that put the lives of mothers and children at risk.

A recent study regarding the benefit of ultrasound in rural areas concluded that pregnant women in low-resource settings often delay seeking care until late in their pregnancy or, worse yet, until labor and delivery commence and life-risking complications arise. This would not satisfy the aim of the Moroccan Ministry of Health for all mothers to receive four antenatal visits during pregnancy. Ultrasound has the potential to significantly improve antenatal care attendance particularly in rural areas of Morocco where most women are not seeking full antenatal care during pregnancy. By word of mouth, mothers learn of the presence of ultrasound at health houses and sought antenatal care simply to receive an ultrasound exam. The appeal of health houses with ultrasound capabilities has a multiplying benefit as women can then receive immunizations, essential medicines, and health education. [57]

Pairing together the two key benefits of ultrasound - increased interest of mothers seeking antenatal care and improved triaging of pregnancies - will likely lead to greater health system efficiencies and improved maternal and newborn health. In rural areas where health houses are underutilized and hospitals are overwhelmed, arming midwives with ultrasound could "right the balance" encouraging women to seek early care at their local clinic. [58]

How do you make such a technology available?

Using an imaging platform with a workflow like the one used in this project is simple. We believe that sharing capabilities should, and will be, an integral part of the actual imaging devices. In order for this to happen the devices need to be connected to a mobile network. There are plenty of ways to make that happen. The devices also need to be very easy to operate and provide tools for training and communicating with others. The devices need to be affordable and robust to be eligible for the poorer markets and rougher environments. It should mirror the experience of buying a cell phone today. The device should be connected right out of the box with basic capabilities for communication and optional features that can be activated individually. They should come with a "data plan" in the same way as when you buy a phone from a carrier you get minutes to talk, text and time to surf the web. A medical imaging device should be no different. The imaging device manufacturers should provide these integrated solutions. But who is the customer?

In some markets the governments that are obligated to provide care and have a state budget should purchase the devices. There could also be a scenario where global health or aid organizations that are funded by donors, like Doctors Without Borders, take on bringing new technology to patients. Portable imaging devices could be a tool in their toolbox, like any other tool.

The biggest issue is finding models that will provide sustainability and guarantee that the technology will, first and foremost, be available to everyone that needs it and, second of all, continue to be available beyond a project or a short-term initiative.

How do we create sustainability?

The Mobile Ultrasound Patrol Project was designed to show what we call "do-leadership." Do-leadership is when you step into action and execute transformational projects to make a point. Do-leadership is an active leadership style – which means not just talking about how things are changing but showing how they change. Do-leadership sometimes resembles activism and it comes with the great privilege of having actual results to demonstrate as opposed to an instinctual, speculative, conceptual story to tell. We targeted superior implementation. Our idea was to show a viable example of what could be done and then share that potential; finding a way to fit it into the huge, and not always well-functioning, machinery surrounding global health. We cannot solve the injustices in access to healthcare. We cannot even provide care. We can merely offer a technology that can provide access to healthcare. We executed a project; we have the results to prove its impact, but how do we go beyond that and create sustainability?

1. Ultrasound needs to be acknowledged as contributor to the definition of high quality maternal care.
2. There needs to be acceptance for using community workers, midwives and nurses to perform ultrasound scans. Part of trainings and knowledge could easily be given during initial education. Basic knowledge for ultrasound should be trained in midwifery schools and universities.
3. There needs to be proof that actual lives are saved. Clinical outcomes need to be accepted.
4. Healthcare economics need to be in place and accepted. There needs to be an insight, or a business case, if you will, that the technology, as such, brings down cost for the provider, reduces cost for transportation of medical images as well as the cost for transportation of the patients for ultrasounds at another location.
5. The devices need to perform according to the basic functionalities: connectable, sharing capabilities, easy to use and affordable.

"There is an obvious way to pass the project phase and become sustainable. That is if a local government picks up the technology or program and internalizes it to the local healthcare policies".

Erin Anastasi, UNFPA.

The leading world health organizations need to go beyond supporting initiatives and projects and to start building general, long-term scalability models. With the same massive power, impact and outcome as they have in putting programs in place they should build infrastructure that can be scaled and replicated to spread innovation across borders.

A focus on sustainability will make a difference in education and medical care. Without it humanitarian projects are only fulfilling a localized need and just scratching the surface of what is possible. Much improvement is required to guarantee roll out and follow-up with a long-term perspective. All of us are tasked with supporting and accomplishing this goal.

What are the hinderers and hurdles to making our mission a reality?

Issue #1:
Technology doesn't empower treatment capabilities

We believe every woman should have the right to high quality maternal care, including ultrasound. It is important to acknowledge, however, that a gap can occur between providing technology with access to diagnostics and the actual ability to then treat the patient. Technology and insight is worthless without the ability to act. Having knowledge and no power to implement is a terrible situation.

Issue #2:
An interdependent healthcare ecosystem doesn't exist

The lack of existing relationships between care providers is a fact. How do you bridge this? In the Mobile Ultrasound Project we built up an artificial ecosystem. We built relationships between leading inner city health facilities, prestigious physicians, rural nurses and doctors. We tied a French-skilled maternal fetal medicine specialist to a midwife. It worked for a project, but in order to make it vital enough to sustain, incentive systems, legal relationships, workflows etc. will be needed.

Issue #3:
It is unclear who holds technology advancement investment responsibility

Money, money, always money. The business model is a hindrance. New technology could potentially save lives and also reduce costs but it comes with an investment. Who should pick up the bill? Who should pay for equipment and training?

Issue #4:
It would be hard to establish a repeatable plan when there are huge national variances in healthcare human resources

There are huge differences in the organization of the different health houses, their presentation and hygiene as well as in the medical performance of the local staff due to a:

- Lack of managing and developing human resources
- Lack of creating partnerships with local communities and civil societies
- Lack of providing continuous training
- Lack of motivation of local staff

Continuous training and education of midwives, generalists in health houses and delivery houses would help to evaluate their work and would make a significant difference in healthcare in rural areas.

Issue #5:
Even donated equipment/materials aren't useful without proper training

Cooperation built up with international associations often results in sponsorship of urgently needed materials and is a great resource that helps rural areas and health houses acquire medical equipment. However, no continuous training after the delivery of the material can create an underuse or even non-use of equipment which otherwise could save lives.

What does the future hold for Mobile Ultrasound 2030?

In conclusion, we leave you with a visual image of how ultrasound will be executed in the near future. In 20 years there will be screens where you can review medical images and share them with others in encrypted secure environments. The image-capturing technologies are connected via multiple technologies and are not necessarily part of the reviewing device, or the screen, at all. Mobile networking is present everywhere. An ultrasound machine costs about as much as an iPhone and comes with a data plan, allowing you to pay just for what you use. Image sharing technology is purchased like any mobile application in an app-store or off the web. Long gone are the licensing fees and maintenance contracts for old-school installable software. We will laugh at the idea of printing a medical image on a piece of overpriced, toxic paper that fades and then calling FedEx to have it sent over to the next city for review. In fact, we will laugh about using pieces of plastic to store data and feel confused when we try to understand how to fit a CD into our portable screens. Maybe we even see patients carrying their own medical data in their pocket, storing it on personal devices and sharing it with the physicians themselves? These things are all possible today.

What's next? What should be done in terms of research, projects etc.?

This project did not make us feel complete. On the contrary, we want to see more. We would hate to see this project become one in a row of fading, slowly dying good ideas that lack sustainability.

We think the next step is a project focusing on proving the clinical outcome and tying the use of technology to the actual desired results, saving lives and ultimately impacting the millennium goals to contribute to lowering the global maternal death rate. We think that both the technology and the workflow model should be put to a real test, implementing the next project in the top five regions on UNFPA's list of countries that have the highest maternal death rates. Other areas of interest to consider would be breast cancer, Tuberculosis and elderly care. What could be possible with mobile ultrasound in those segments?

Finally, with three mobile ultrasound devices, a group of technology companies and passionate healthcare providers on a very limited budget and no clinical environment managed to prove, in under 8 weeks, how the country of Morocco could save an amazing $1,680,000 USD yearly on transportation for second opinion. The surplus could be invested in mobile ultrasound and advanced wireless technologies and perpetuate better healthcare, sustainably.

This project scaled to a national level could mean 120,000 high-risk pregnancies could be identified with remote diagnostics and reduced to 56,000 high risk pregnancies needing special care after a remote diagnosis.

If we could do this, what might be possible if the technology where available via global health organizations that have the network, the caregivers and local representation globally? Or what could be possible if the technology was available via the public healthcare systems globally? How many lives could be saved?

What could be possible?

Dr. Mohcine Wahbi
- Obstetricien CHU Fès

Working in a hospital is one way to help pregnant women but participating in a caravan and seeing the need for medical care in really poor regions showed me that everybody should contribute some time in his life to helping those people. They were so grateful to us, received us with open arms and even invited us to have lunch at their private homes.

In November 2013 Professor Melhouf from the CHU Fès asked me if I could join him for a project in Ribat el Kheir for mobile ultrasound. I confirmed immediately. All the participants met in Rabat where we were trained on the scanning equipment, according to the medical protocol. Together we discussed the goals of the project – which was highly motivating for all of us.

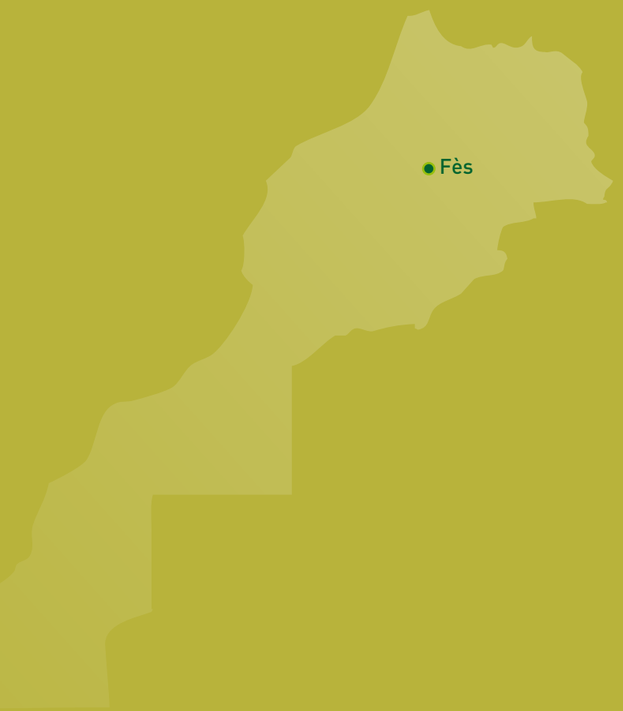
On the first day of our mission in Ribat el Kheir a pregnant woman arrived ready to deliver. In the first minutes the midwife and the doctor determined that the baby was in a "seated" position Normally, the patient would have been prepared to deliver by cesarean but it was too late because the delivery was already in progress.

I was able to assist during the very challenging delivery and contributed my help and knowledge to the midwives until this baby finally arrived. Verena performed the first exams and checked the reflexes of this little boy, making sure that he did not need help before returning him to the arms of his family.

In my opinion that kind of a surprise could have been easily avoided with a simple ultrasound. The team and the mother would have been prepared and there would have been time to transfer her to an adequate location. Unfortunately, this patient never had an ultrasound during her pregnancy.

We went back to our team afterwards and had a great lunch in the health Center, organized by the locals. Hospitality is amazing in those rural areas!

Being part of this trial was wonderful and I am so thankful. Let's continue to contribute and make it happen again and again.



Field Story

Said and his wife – living in Fès

Acting as a driver to the team was a pleasure. We shared the entire two weeks together and had a lot of fun. It was an impressive experience with nice evening discussions and all of us felt sad to leave at the end.

Fortunately, I was able to bring my whole family to Oulmes during one of the weekends to stay with the team and I had the pleasure of assisting with the ultrasound of my pregnant wife, together with our daughter.

The team transmitted our images by the wireless technology and within half a day we got a second opinion from a referring physician. He informed us that we will be having a boy, that everything is perfect for the moment and that he will be born next June. We could see the images of our baby on the technology and were able to transmit them to our families.

Thank you for helping all those women to get an ultrasound exam during their pregnancy, informing them about the health of their fetus, explaining to them if they might need assistance for delivery and giving them the chance to be transferred in time so their children do not grow up motherless!!!

Executive summary

"Access to new wireless technology is not only cost efficient and time efficient, it also gives access to professional diagnosis expertise, improves medical quality and decreases the cost of medical coverage for pregnant women in rural areas." [59]

Dr Chrit

The majority of childbearing related deaths occur in developing countries within rural areas and among poorer communities from complications that develop during pregnancy. Most of these deaths occur where ultrasound imaging during pregnancy and delivery is currently underutilized and financial constraints have been cited as the main reason. The healthcare solutions to prevent or manage pregnancy and childbirth complications are well known, making many maternal deaths avoidable. Advances in ultrasound technology - smaller ultrasound image-capturing devices, data encryption, data storage and Internet connectivity - enable ultrasound to be available in places not previously convenient or economically reasonable. The UN, WHO, UNICEF, UNFPA and others have developed initiatives to focus on addressing these underlying causes and examine possible solutions.

Maternal mortality is a priority for the Moroccan government as the population composition indicates particular vulnerability to this issue. In 2008 the Ministry of Health (MOH) developed specific actions in The Moroccan National Acceleration Plan for 2008-12 to hasten the reduction of maternal mortality. Furthermore, Morocco is one of 57 countries suffering from a severe lack of healthcare professionals and remains extremely vulnerable to their exodus to other countries. This lack of resources is exacerbated by unequal allocation of human health professionals between rural and urban areas and within the different regions of the Kingdom.

In support of the efforts of global initiatives and, specifically, the Moroccan Ministry of Health, The Mobile Ultrasound Patrol Project was created, financed and powered by a collaboration between Trice Imaging Inc., Qualcomm Wireless Reach™, SonoSite Fuji Film and Sony. To test the technical capabilities of technological options for rural Morocco, these groups provided advanced wireless communication and collaboration technology supporting connected portable ultrasound devices and subsequent remote access to state-of-the-art imaging diagnostics in 3 small rural villages via mobile networking.

Results in summary:

- Cut the time for diagnostic review or second opinion time from two weeks to fewer than 24 hours and reducing the cost from $80 to $2 per patient
- Cut the time for transportation of the medical data for review from four days to two seconds
- Increased the medical practitioners' (midwives, nurses and general practitioners) skills to deliver ultrasounds from 20% sufficient for diagnostic purposes to 92% sufficient for diagnostic purposes

Time Efficiency

The Mobile Ultrasound Patrol Project showed that using wireless technology and a Cloud-based system would make a significant difference in medical care in a region like rural Morocco. These technologies not only help the image-capturing physician or midwife to quickly make appropriate decisions; they efficiently connect health houses to second opinion expertise at regional and University hospitals, all of which saves the patient time.

Out of the 113 patients, 24 cases were diagnosed as risk pregnancies by the image capturer due to the ultrasound examination or patient history. For 17 patients (71%) out of those cases the responding time was less than 24 hours. For 7 patients (29%) more than 24 hours were needed.

70%of the 113 examinations were transferred within 1 minute to the wireless platform and from there to the referring physician for a second opinion. Another 26% of the transmitted examinations needed less than 2 minutes of transfer time.

The time it takes to get a second opinion using traditional procedures in this region could decrease from an average of 2 weeks to an average of 2 days by using advanced wireless technologies.

Time scenario

	Normal Scenario	Project Scenario
01 Transportation of data	2 days to 2 weeks	**<1 minute**
02 Transportation of patient for second ultrasound	2 hours to 4 weeks	n/a
03 Time to diagnostic response	2 days to 2 weeks	**< 24 hours**

Cost Efficiency

When women visit a Moroccan health house the cost for an ultrasound runs about $40 USD. If it is determined that a patient requires a second opinion and ultrasound, they are transported via ambulance to the nearest regional hospital, which costs the government another $40 USD for the transport and $40 USD for the additional ultrasound. The Mobile Ultrasound Patrol Project showed how image management solutions, which transmit images to a referring physician via the Internet, instead of the patient, dramatically decreased traditional costs.

Cost scenario

	Normal Scenario	Project Scenario
Cost of Transportation of data 46 patients	40 x 46 = $1,840 USD	**2 x 46 = $92 USD**
Cost of uls for second opinion for 46 patients	40 x 46 = $1,840 USD	n/a
Total costs	$3,680 USD	**$92 USD**

Total saving: $3,588 USD

Quality

From a medical perspective and due to the actual technical requirements and equipment, 80% of the images taken in health houses before training could not be used for professional diagnosis.[60] During the trial, all 113 studies were evaluated on transmitted image quality for both technical and medical purposes. Of the images collected, 86% were considered "excellent" and 92% could be used for professional diagnosis.

Compared to traditional rural Moroccan health house methods, the wirelessly-transferred Mobile Ultrasound Patrol Project examination solution was everything the team had hoped it would prove to be: high quality, faster and less expensive. In addition to proving the viability of the technical solution, the outpouring of gratitude and enthusiasm from the medical professionals, health officers and families in Morocco confirms that the solution addresses the intangible powers of proper care that run deeper than an ultrasound exam.

Ultrasound has been described as a "sustainable technology" for developing and low-resource countries, because of its relatively low cost of purchase, low cost for maintenance and supplies, portability, and durability in comparison with all other imaging modalities (Goldberg, 2003).

The addition of technology solutions and proper training methods, like those used in the Mobile Ultrasound Patrol Project in Morocco, implies that the early detection and diagnostics that can ultimately reduce maternal and child deaths across the globe are possible now – in less time, at a high quality and lower cost than current methods.

Imagine what could be possile if there where global access to wirelessly connected mobile ultrasound?

Image quality

	Normal Scenario	Project Scenario
Transmitted image quality approved	20%	**92%**

Footnotes

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Oulmes
Boulemane
Ribat el Kheir

Trice IMAGING
IMAGES IN A HEARTBEAT

QUALCOMM
Wireless Reach

SONY

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FUJIFILM