Baby Tempit

Abstract

Infant mortality and morbidity rates can be greatly reduced with early detection of the signs and symptoms of illness including infection and hypothermia during the neonatal period (the first 28 days of life). Providing adequate training and tools to Health Auxiliaries (HAs) who are often the first point of contact for rural populations, is a proven method to improve outcomes. Furthermore, accurate temperature measuring and monitoring is a key identifier of illness, and simple tools to accurately measure the temperature of a neonate are critical to this assessment.

Currently, there are no temperature measuring devices that meet the needs of these HAs with limited literacy or that are specific to the global health protocols for axillary temperature measurement of the newborn. Comprehensive, graphic training materials are also not available in low resource settings. Team Krest seeks to address these gaps by co-creating, designing, and developing a simple and innovative temperature measurement device that is specific to the neonatal anatomy, accurate in its read-out, and appropriate for the HAs of the Tribal Health Initiative (www.tribalhealth.org) in the home and village setting. Additionally, a training and informational graphic (Appendix A) will be integrated with the measurement device to provide a comprehensive system that supports early detection.

Neonatal Temperature Measuring and Monitoring

India's overall infant mortality rate (IMR) is 44/1,000 live births and 31 of those babies will die during the neonatal period (first 28 days of life) (UNICEF, 2012). Many of the causal factors relating to neonatal mortality are preventable with early detection and treatment. Team Krest seeks to address this important issue in maternal-child health (MCH) by identifying solutions to promote timeliness in access to adequate healthcare for newborn babies.

Our investigation into the current protocols for neonatal assessment and monitoring indicates that hypothermia and hyperthermia are early indicators of illness and therefore, critical in the assessment of neonates (Lunze et al, 2013). Furthermore, the majority of neonatal deaths occur at home in low-resource settings with weak healthcare systems. A simple tool for temperature measurement, a digital thermometer, is rarely available to community health workers (CHWs) who are the first point of contact into the healthcare system. Additionally, CHWs often have limited literacy or are nonliterate, making it difficult for them to interpret the digital read out and facilitate appropriate treatment.

According to the global standards for neonatal assessment, the axilla or armpit is the best location for temperature measurement of the neonate (King Edward Memorial Hospital, 2014). The rectum was the preferred site prior to recent research showing rectal measurement increasing the risk of infection or injury to the baby. However, the change to the axilla has left some confusion as to what is within the ranges of low, normal, and high. Our project seeks to resolves this issue as well.

Our project is based on ethnographic data we collected from stakeholders affiliated with the Tribal Health Initiative of the Dharmapuri District of Tamil Nadu state in southeastern India. The nearest governmet hospital

is 48 kilometers away and surgical center a distance of 100km. Tribal Health Initiative (THI) serves the "Hill Tribes" in 33 surrounding villages, a subsistence farming region in the Sittilingi Valley which had been completely without healthcare access before THI built its first small health center 23 years ago.

Community Description

The Founders of The Tribal Health Initiative

The Tribal Health Initiative was founded in 1992 by Dr. Regi George (photo above) and his wife Dr Lalitha Regi. Regi shared with our team that Gandhi has strongly influenced his life, leading him and his wife to live simply, in harmony with their environment. The doctors spent one year travelling around India to find a community where they could be of service. They settled in the Dharmapuri District and began serving the tribal people in this region. In the beginning, the doctors started seeing patients in a hut under a tamarind tree. It took time for them to gain the trust of the hill tribes due to differences in customs and beliefs. The first turning point came when a villager called them to treat a woman dying of diarrhea/ dehydration. They stayed through the night to treat the patient at home and the woman survived.

When THI first began to have a presence in the Dharmapuri District the infant mortality rate (IMR) was 147/1,000 live births. The current IMR is 20/1,000, a remarkable reduction! Maternal mortality rates (MMR) were also high but the THI has not had a maternal death in 10 years. THI has also established programs that address other factors that influence the health of populations such as nutrition (food) security, economic stability, and education. Additional information is available at: www.tribalhealth.org

Available, affordable, and acceptable healthcare are the three pillars on which THI stands. The doctors believe in a people-centered approach to healthcare that is long term and holistic with local solutions such as trained health workers coming from the tribal communities. THI has a four-tiered healthcare system that is integrated and cohesive. An interesting aspect of this structure is placement in first position of primary care delivered by village HAs, followed by Village Health Nurses (VHNs) supporting the HAs. Medical doctors are consulted third in the system (third tier) and treat patients at the THI hospital. Outside researchers are in the fourth tier.

Tier 1 – Junior and Senior Health Auxiliary (HA)

Each village has designated one woman to be trained as a Health Auxiliary (HA). She offers advice on good nutrition, hygiene, birthing practices and simple ailments. She maintains records and facilitates all community development work. HAs are the first point of contact in the primary health care system of THI, serving as a bridge between the village residents and the health center. Patients will often ask their HA to accompany them to the clinic for treatment.

Sathiya, is a 46 year old senior HA (1 of 6 seniors, see above photo) from Velanoor Village in the Sittlingi Valley. At the time of her recruitment by THI 13 years ago she was working in the government school lunch program. When Sathiya started with THI, she was nonliterate. Now she can sign her name and read numbers. Her initial training lasted for three months, followed by three years of training under the mentorship of Dr. Lalitha. She has experience delivering babies at home, dispensing pharmaceutical medications, and knows

native treatments for common health conditions. When the opportunity presents itself, Sathiya also educates the women of her village about healthy pregnancy habits and infant care.

The junior health auxiliaries are the most recently trained HAs. They have been primarily trained to monitor and treat chronic diseases such as hypertension and mental illness. Dr. Regi informed us that this has left a gap in the maternal-child health (MCH) system, since the new HAs are not yet skilled at working with mamababy. Only six of the 25 HAs have been trained in MCH, which THI is planning to offer to the junior HAs in future.

Lakshmi is a 30 year old HA recruited after being asked by THI if she would be interested in being trained. She is still in training, and is eager to expand her knowledge and skills to better serve her community. Like many if not most village health workers, she has children (she has 3 children ages 12,11 and 7), and must have the support of her family as well as her community to do her work while being a mother.

It is this group of stakeholders, the HAs, for whom our thermometer and graphic training material are primarily intended. They have expressed a sincere interest in learning to take accurate temperatures and as one HA told us, "We will use any tool you give us." Dr. Regi has informed us that the junior HAs have not had adequate training in MCH, so our training graphic (chart) is intended to provide a teaching tool to improve the knowledge base and skills of these newer HAs.

Tier 2 –Junior and Senior Village Health Worker (Nurse)

The village health nurse (VHN) offers the next level of care. She is also a liaison between the tribal villagers and THI. She is more highly trained, experienced, and skilled than the HA. VHNs are cross-trained to work in the outpatient clinic, laboratory, labor and delivery, surgery, and infection wards of the facility. She trains junior nurses and HAs by taking an interest in their job performance while setting an example for them to follow. She does all jobs, big or small, from cleaning toilets to assisting with surgeries. The most senior VHN, Madheshwari told us, "If I don't do the small jobs I will forget them." At the same time she proudly told us she does virtually the same work as the doctors and has their complete trust.

Madheshwari was 18 years old when the doctors trained her 18 years ago. After several visits with the family by Dr. Regi, she decided to work at THI against the wishes of her parents who wanted her to continue working in the fields. Now her family, including her husband, is very supportive of her work as a VHN. He takes care of the children when she works and even drives her in the middle of the night to attend emergencies.

Madheshwari had only attended school until the 10th grade when Drs. Regi and Lalitha trained her in the first cohort of health workers for 3 years. She has earned the trust and respect of her community because she goes beyond the call of duty when anyone or the hospital needs her. The community trusts her as much as a doctor.

The Mothers

It is important that we not exclude the mothers in our discussion of stakeholders. In our meetings with the THI staff, it became apparent that while the initial focus is on meeting the needs of HAs for training and tools with which to perform their jobs, the long-term plan includes passing this knowledge on to the mothers. Or as Dr. Regi so eloquently put it, "instilling our knowledge into the collective community memory."

We spoke with a 20 year-old mother with an 8th grade education who had delivered a baby boy at the government hospital five days prior to our interview. She was married at the age of 17 and her husband is a daily wage laborer. She lives 50 km away, which requires taking 2 buses to get to the THI. For her most recent pregnancy she had all her antenatal check ups at THI. This young mother lost her two previous infants within days of their births. Both were born at the government hospital and she was not informed of the cause of death. However, both babies were very low birth weight as well as premature. Her current baby weighs 2.3kgs and she carried him to term. This mother informed us that she brought her baby to THI as soon as she was released from the hospital because she trusts the staff and believes she and her baby are getting good care there. She also told us that she was not aware of the danger signs of illness to look for in her baby.

Problem Framing

The following four points describe our problem framing (see also our team's joint Design Notebook)

- Two primary causes of infant morbidity and mortality (infection and hypothermia) can be detected with temperature monitoring.
- Early detection and management improves health outcomes for the neonate (first 28 days of life).
- We have designed a simple, innovative thermometer that improves the ability of community health workers (CHW) to measure and monitor neonatal temperature in home settings.
- Furthermore, we have created a training tool to help the CHW assess signs and symptoms of neonatal illness. The tool is in the form of a chart whose content was co-created with the THI nursing staff.

Design Process

HAs wish they had tools to help mothers make early, informed decisions regarding newborn health because, as the first point of contact, HAs are integral to the health and well-being of their communities. We addressed this need by co-creating a system that integrates a device to measure and monitor the baby's temperature with a neonatal teaching and assessment tool.

Prior to creating our Problem Framing Tree, we identified some of the primary causes of infant mortality and morbidity. Of these seven causal factors, three were identified as priorities by THI: nutrition, hypothermia, and infection. We chose to create our Problem Framing Tree from the two factors relating to neonatal temperature measurement and monitoring because they fall within the scope of a project we could realistically design.

Figure 1 - Causal Factors of Infant Mortality and Morbidity

Problem Framing Tree

Our Problem Framing Tree is rooted in addressing hypothermia and reducing infection. The hyperthermia branch has two main branches: reduce infection and reduce cold exposure. The 'reduce infection' branch has three smaller branches, and our focus is on the 'detect infection early' branch. Note that 'reduce infection' appears on both of the main branches.

Figure 2 - Problem Framing Tree - Hypothermia Branch

Figure 3 - Problem Framing Tree – Infection Branch

Value Proposition

Empowering HAs to do their jobs with certainty and accuracy will increase access to quality care for mothers and babies. Having simple, easy to use professional tools will also build trust and credibility with mothers in the community. Combined with the 'Signs and Symptoms of Neonatal Illness' graphic, accurate temperature measurement provides information needed for mothers and HAs to make informed choices about neonatal health. This chart is designed to integrate within the existing training framework at THI.

The Baby Tempit thermometer will provide validation to the HAs of the sensory knowledge and experience that has traditionally been the method for temperature measurement. (Mercury, not digital thermometers have thus far only been used in the THI hospital). For less experienced health workers and in future for mothers, Baby Tempit measurements will be even more critical to accurate, reliable assessment. Our thermometer has been designed specifically for axillary use, thus reducing the risk of inappropriate rectal or oral use. The intuitive shape ensures that the device is easy to use by care providers. The colored range graph and sliding indicator bar provide visual information needed for nonliterate caregivers. The indicator light on the thermometer tip will blink while temperature is being measured and glow solid when the temperature has reached its highest point.

Summary of the Design Process

Prior to going THI we thought that our stakeholders were:

1) Mother/Baby
2) VHN (Village Health Nurse)
3) Village Leaders
4) Older women
5) Doctors at THI

Following the first trip to THI we determined that our primary stakeholders are:

1) Mother/Baby
2) VHN
3) HA (Health Auxiliary)
4) Doctors

We followed our data collection strategy to use participant observation and semi-structured interviews to collect information from the HAs, VHNs, doctors, and mothers. Following analysis of this data, we discovered the need for a thermometer that was specific to axillary temperature measurement of the neonate and a possible baby warmer for use by the HAs in the village setting. This information guided us to our problem framing statement.

On our return to Chennai, we worked on idea generation using brain writing and brainstorming. The 125 ideas generated during this process were placed into three categories: monitoring, maintenance, and education. Our discussions led us to conclude that a thermometer specific to neonatal axillary temperature integrated with an educational tool would be a valuable, if ambitious project to co-create.

At our second visit to THI, we again used participant observation and semi-structured interviews, and added two focus groups with VHNs, HAs, and another physician to our methods. In our meetings with the doctors, VHNs, and HAs, we collaborated on initial design concepts for a thermometer and an educational/informational graphic titled, "Neonatal Signs and Symptoms of Illness".

We researched protocols and standards of neonatal temperature measurement and monitoring, and discovered there is much confusion around oral/axillary and rectal temperature interpretation. We also discovered there is no temperature measuring device that can be used by nonliterate healthcare workers and those with limited literacy. Our team reviewed the problem statement many times during the design process and used bisociation methodology to finally come up with our prototypes.

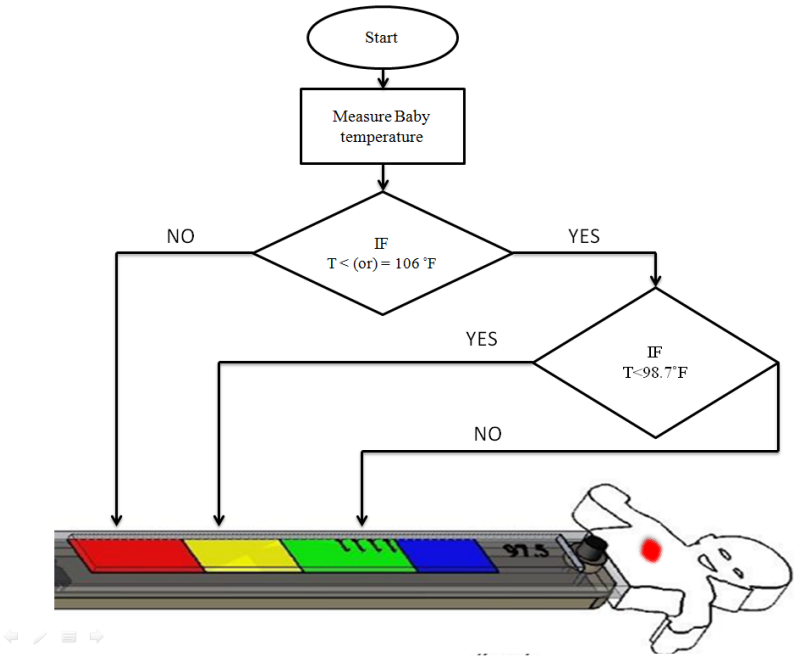
Analysis and experimentation

There is nothing to present here, since we are not yet at this stage of product development.

Technology/Final Prototype

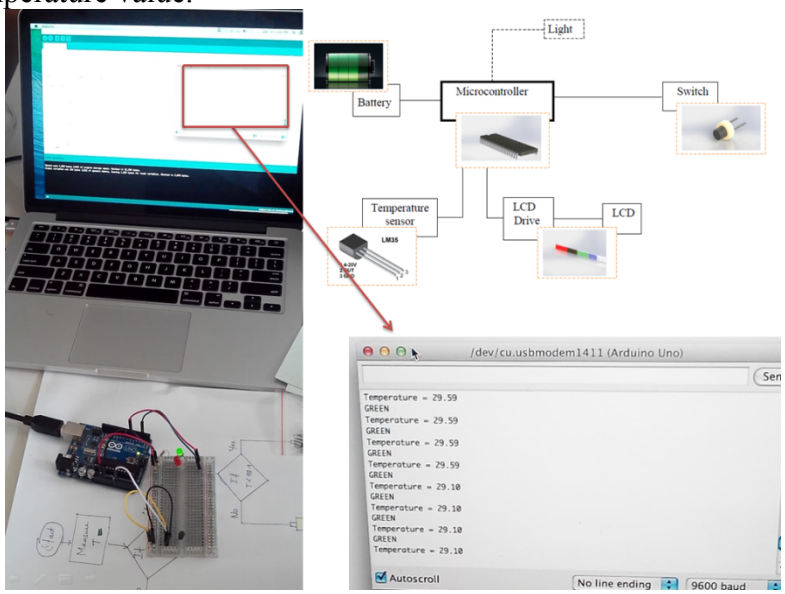
Design Requirements

One of the main design requirements is a temperature-sensing device with high accuracy and certainty for a human body temperature range of 95 ˚F to 105 ˚F. In order to read the temperature and indicate the risk level of a measured temperature using a color range indicator, the product's microcontroller is programmed based on the logic shown in the figure below.



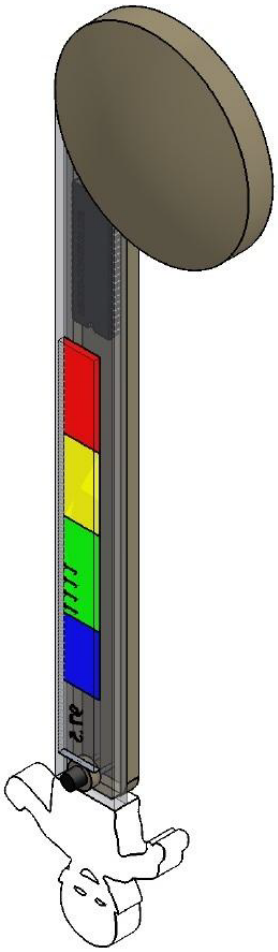
The microcontroller is programmed using Arduino open source software. The analog output of the temperature-measuring sensor is given to microcontroller port A_0. The HIGH or LOW output of the

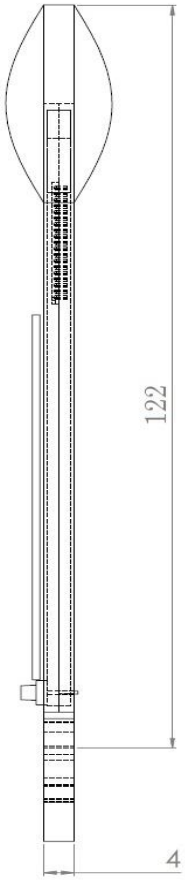
microcontroller from a specific microcontroller port is given to an LED with specific colors indicating the risk level of the measured temperature value.



How Does It Work?

The basic thermometer shape was arrived at, as shown in the figure with a glowing baby[(1)] at one end and temperature measuring sensor at the other end. This thermometer is especially designed to measure the temperature under the newborn's armpit, which is the very safest and most infection-free way. The temperature measuring instrument will also indicate the risk level through a color range indicator[(2)]. Color range indicates the course of action for health workers or perhaps, mothers after measuring the temperature. In the LCD display we have Blue, Green Yellow, and Red temperature zones.

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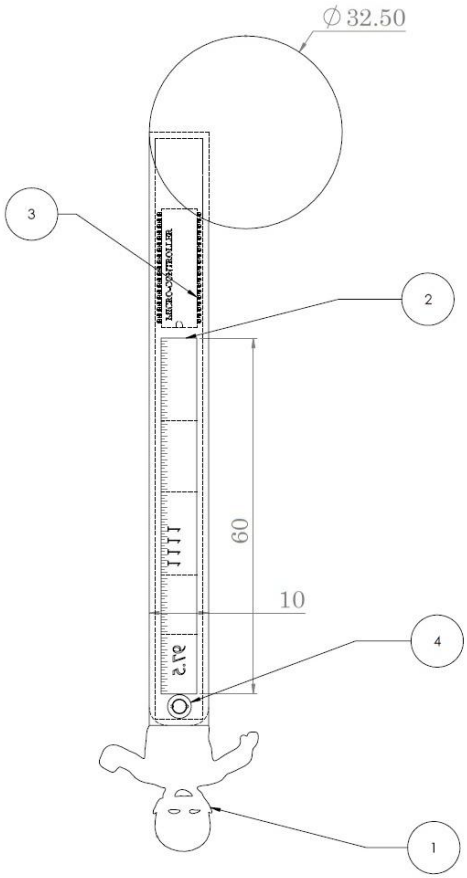
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The Blue range indicates the temperature that is below normal body temperature (99.6 F), indicating a need to monitor the infant for hypothermia. The green range indicates that the temperature of the baby is normal. The yellow range indicates an at-risk temperature that has to be monitored for fever and/or infection. And the red range indicates that the baby has to be transferred to the hospital immediately.

Bill of Materials

Part No	PART NUMBER	QTY	Material Description
1	Baby Thermometer Outer Cover	1	Abs (Acrylonitrile Butadiene Styrene)
2	LCD Scale Indicator	1	
3	Microcontroller	1	
4	Start/Stop Button	1	
5	Plastic Baby Head (Transparent)	1	PMMA (Poly Methyl Methacrylate)
6	LED under transparent doll head (measuring process indicator)	1	
7	PCB (Printed Circuit Board)	1	
8	Temperature Measuring Sensor	1	

Lessons Learned

Community Engagement

Team Krest visited THI and several villages on two occasions to collect data relating to neonatal temperature measurement and monitoring. We used methods that included participant observation, focus groups, and semi-structured interviews. We met with various stakeholders in the community and collected field notes and pictures. The doctors, HAs, VHNs, and mothers provided us with valuable insights into the realities of MCH (mother child health) in the Dharmapuri District and at THI. Our interactions were positive, informative, and inspiring. The people-centered model of healthcare promoted and lived at THI shows how local solutions can be life changing for those who are often underserved by governments and the current global health system.

User Feedback

On our final day at THI we conducted a focus group with the facility's doctors, nurses, and a couple of the HAs. Using a co-creation process we identified the categories for the "Neonatal Signs and Symptoms of Illness" chart (Appendix A) and received their feedback regarding desired standards and protocols. It was a very productive co-learning opportunity with our team and within the THI team.

During prototype development we emailed the chart to Dr. Regi and received his feedback. For example, he appreciated the depth and detail of the chart, and questioned the 'Crying' category. He asked how a newborn was going to tell us if they had a headache, earache, or stomachache. We replied that the HAs had described their methods of assessment, which we then reflected in the chart. We have since sent a colored copy (8 x 14 inch) of the chart to THI to begin using it in their trainings of the HAs.

Troubleshooting

At this time, we have nothing to report. Until a working prototype is created and a training program conducted, we are unable to know what potential problems may arise.

Next Steps/Project Future

Reflection on Project Viability and Other Design Opportunities

Stakeholders (outside of our team) who have expressed interested in helping us move our project forward:

- Dr, U. Sabura Banu, Professor, Department of Electronics and Instrumentation Engineering, BSAU
- Dr. T.R. Udaya Kumar, CEO, Impetus Healthcare Skills
- Paul Belknap, Investor Manager, Vilgro

Moving forward, as we engage more human resources some of our core team plan to continue product development, while others may serve as advisors and conveners of a growing group of technical experts.

Continuity/Dissemination Model

In the spirit of co-creation, we plan to continue prototyping and developing both our Baby Tempit thermometer and the "Neonatal Signs and Symptoms of Illness" chart (teaching tool) as needed. We will develop a 6-month plan to include user feedback based on pilot testing and experimentation.

The team plans to apply for an IDIN microgrant to support prototype development and collection of community feedback. We have also requested a formal design review from IDIN experts.

6 Month Plan and Team Engagement (Roles and Responsibilities)

Over the next 6-months, our team plans to stay involved as we all are able to support the next steps of prototyping; gaining concept and design feedback from a variety stakeholders; and developing networks.

Prototyping

Our team is fortunate to include two members of the BSAU community – Surya Rajan, Assistant Professor in the Department of Mechanical Engineering, and Thilagarajan Palanivel, earning his B.Tech in Polymer Technology. Surya will lead the next phase of prototyping, utilizing expertise and other resources at BSAU to conduct a materials and structural analysis of the thermometer. We expect to have a working prototype in 4 months, at which point we can utilize our existing networks of health institutions to test and provide feedback on its usability and desirability. This network includes Rohini's connections with Kauberry (private hospital where she currently works) and Changalpettu (government hospital and medical college in Chennai where she was formerly employed). In meeting with Mr. Murugesan, Registrar for B.S. Abdur Rahman University and Dr. Banu on July 31, we were strongly encouraged to collaborate with the University, which is able to offer technical resources, faculty & student assistance, and perhaps a small seed grant for product development.

User Feedback and Networks

There is also opportunity to stay involved in co-creating both the Baby Tempit thermometer and the "Neonatal Signs and Symptoms of Illness" chart with Tribal Health Initiative. Rohini has an interest in becoming more involved with THI in the future and could assist with bringing both tools to THI and testing them with Health Auxiliaries in the villages. There is also opportunity to leverage ayzh's (www.ayzh.com) ongoing relationship with THI (via funding from Every Mother Counts) to support and enhance THI's Health Auxiliary training around maternal and newborn health. Should this project continue to the clinical trials stage, Sudy will leverage her Oregon State University affiliation for research design and institutional review board approval. She will then use her field sites in Sierra Leone as another location for clinical trials.

Communication and Funding

Design Facilitator, Kay Sandberg, will take the role of coordinating communication between team members and researching potential funding opportunities, including coordinating our microgrant proposal to THI. Colleen will keep the team informed on the collaboration between THI and ayzh to further develop a maternal and newborn training program at THI, and additional opportunities for partnership.

Contact Information List

Stakeholders

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Team Members

Team Design Facilitator – Kay Sandberg – sandberg.kay@gmail.com (MA; President, Global Force for Healing; www.globalforceforhealing.org/project-one/, Ashland, OR)
Colleen Lyon – colleen@ayzh.com (MBA, part-time employee of ayzh, working with Zubaida Bai, CO)
Surya Rajan – suryarajan.b@gmail.com (Faculty; Ph.D candidate in Mechanical Engineering at BSAU)
Dr. Rohini Rau – rohinirau@gmail.com (local physician in Chennai)

Sudy Storm – sudystrom@gmail.com (midwife, herbalist and MPH, Oregon State University)
Thilagarajan – thilakt20@gmail.com (senior at BSAU majoring in Polymers Engineering)

Partial Bibliography

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2014 Thermoregulation: NCCU Clinical Guidelines.

Lunze, Karsten, David E. Bloom, Dean T. Jamison and Davidson H. Harner
2013 The Global Burden of Neonatal Hypothermia: A Systematic Review of a Major Challenge for Newborn Survival. BMC Medicine; 11-24.

Slide Presentation at 2015 IDDS Aarogyam by Dr. Udaya Kumar, July 2015.

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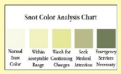
2012 India Statistics http://www.unicef.org/infobycountry/india_statistics.html; electronic document accessed on 7/29/15.

Appendices (3 Posters Presented on 7/31/15)

Appendix A	Neonatal Signs and Symptoms of Illness (chart)
Appendix B	Baby Tempit Prototype Design
Appendix C	Overview of Baby Tempit by Team Kcrest

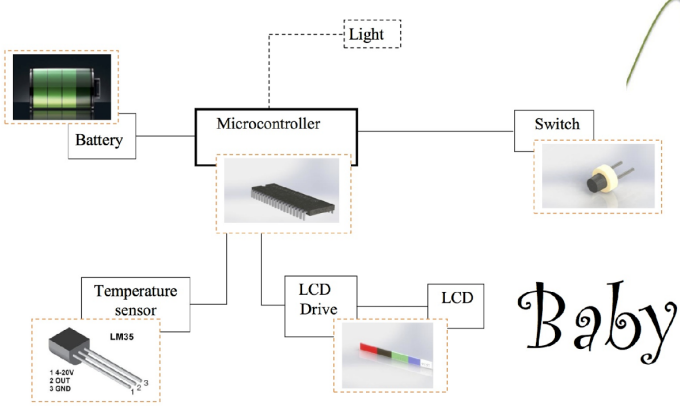
Appendix A

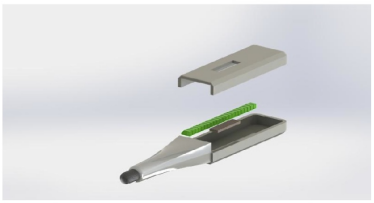
Neonatal Signs and Symptoms of Illness

	Temperature	Crying	Activity	Vomiting	Diarrhea	Feeding	Respiration	Urination	Color
Healthy 	Normal Axillary 96.8- 99.6 	 Less than ½ hour	 Active Responsive	 Milk?	Less than 15 No other symptoms  Yellow or brown	 2 hours	Rate 40-60  Herbal steam Mucus white or clear	 6-8 nappies in 24 hours	 Pink  Yellow face/eyes
Monitor 	**HYPOTHERMIA** Temperature below 96.8 Cover and warm 99.7-100.6  Sponge for 20 minutes 	 ½ hour or more Check for headache, ear or stomach pain, fever	 Can you wake the baby up?	 Milk? After feeding  Burp	Up to 15 loose stools – no other symptoms  Yellow or brown	 3-4 hours  Latch & position Nipple & Infection	Rate 40-60  Mucus green or yellow	 3-5 nappies in 24 hours	 Pale  Yellow above nipple
Transfer 	 100.7↑ Transfer to hospital	 ½ hour or more Continuous Type	 Limp, floppy, not responsive	 Vomiting  Inhale	  More than 15 times Color Odor	 4 hours ↑	More than 60 or less than 30  Chest indrawing	 Less than 3 nappies in 24 hours	 Blue  Yellow below nipple

This graphic was co-created by the KCrest IDDS Team with the Tribal Health Initiative (THI). The THI medical staff shared this information for purposes of establishing standardized protocols for neonatal care and as a training tool for Health Auxiliaries. Additional protocols and standards of care from additional sources were integrated into the graphic. Sources available on request. July 2015

Appendix B





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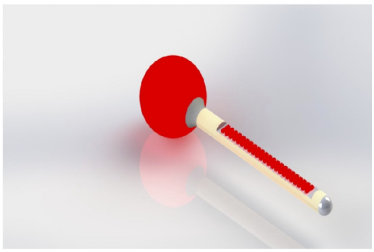

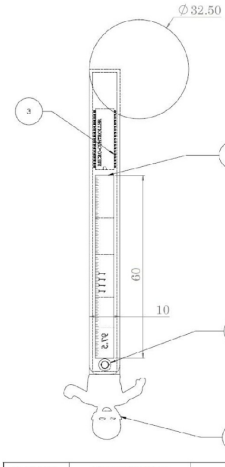

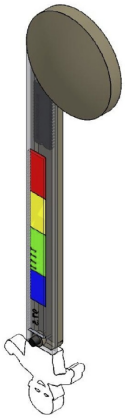

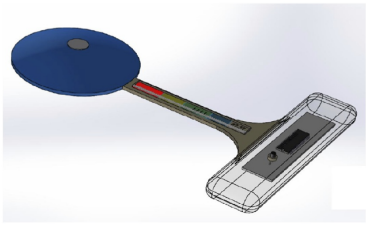

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
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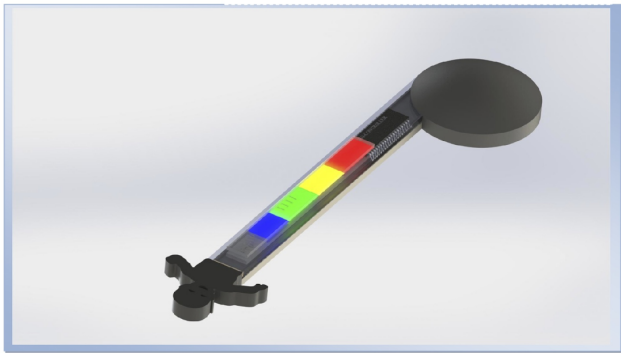
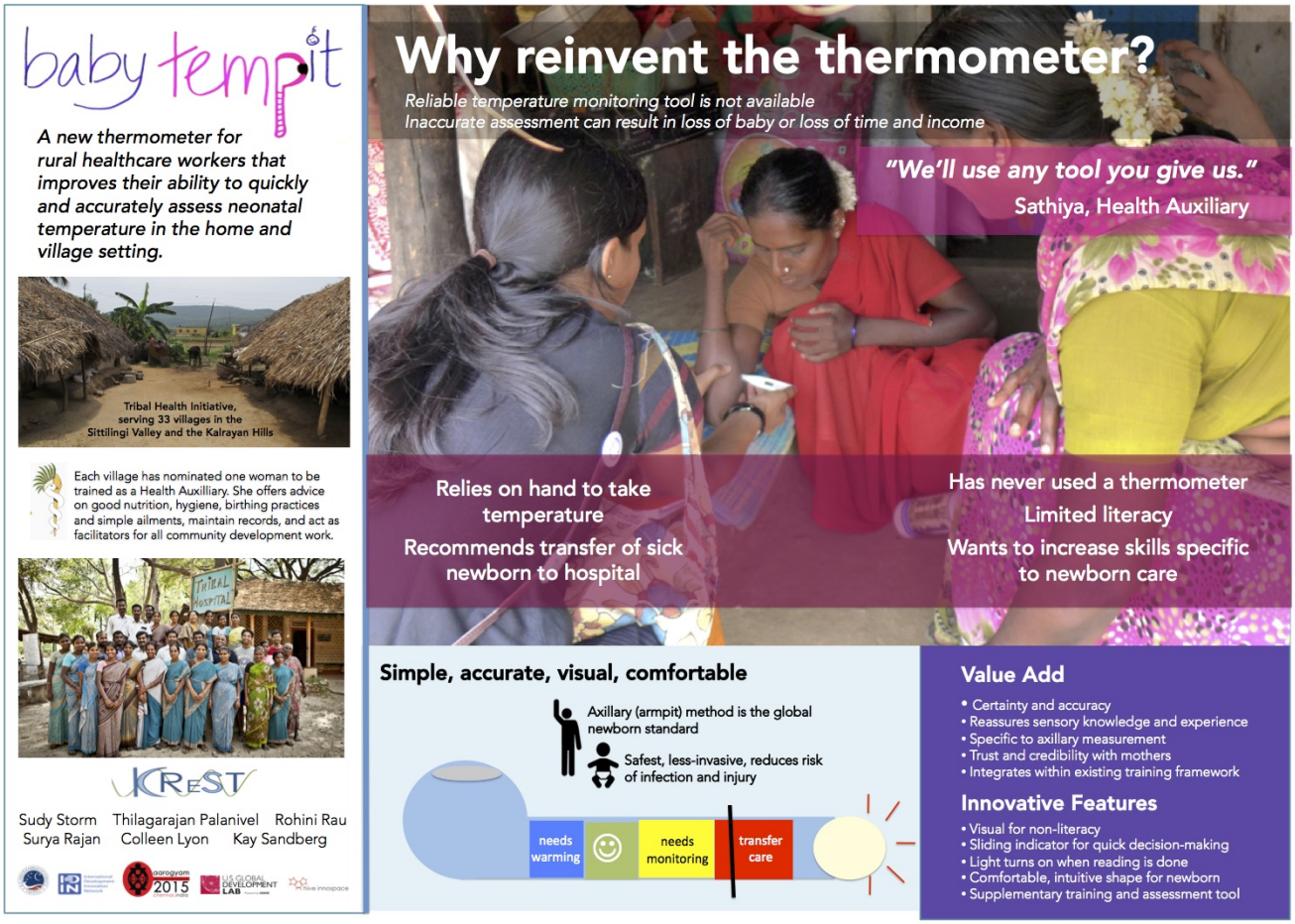
2	LCD SCALE		1
3	MICROCONTROLLER		1
4	START/STOP BUTTON		1



Appendix C


baby tempit
A new thermometer for rural healthcare workers that improves their ability to quickly and accurately assess neonatal temperature in the home and village setting.
Tribal Health Initiative, serving 33 villages in the Sittilingi Valley and the Kalrayan Hills
Each village has nominated one woman to be trained as a Health Auxilliary. She offers advice on good nutrition, hygiene, birthing practices and simple ailments, maintain records, and act as facilitators for all community development work.
TRIBAL HOSPITAL
KREST
Sudy Storm Thilagarajan Palanivel Rohini Rau
Surya Rajan Colleen Lyon Kay Sandberg
Why reinvent the thermometer?
Reliable temperature monitoring tool is not available
Inaccurate assessment can result in loss of baby or loss of time and income
"We'll use any tool you give us."
Sathiya, Health Auxiliary
Relies on hand to take temperature
Recommends transfer of sick newborn to hospital
Has never used a thermometer
Limited literacy
Wants to increase skills specific to newborn care
Simple, accurate, visual, comfortable
Axillary (armpit) method is the global newborn standard
Safest, less-invasive, reduces risk of infection and injury
needs warming
needs monitoring
transfer care
Value Add
• Certainty and accuracy
• Reassures sensory knowledge and experience
• Specific to axillary measurement
• Trust and credibility with mothers
• Integrates within existing training framework
Innovative Features
• Visual for non-literacy
• Sliding indicator for quick decision-making
• Light turns on when reading is done
• Comfortable, intuitive shape for newborn
• Supplementary training and assessment tool