

GLOBAL HEALTH

Innovation Insight Series



The NeoNurture car parts incubator

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DESIGN THAT MATTERS: Designing Contextually Appropriate Products

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THE PROBLEM/SOLUTION SPACE

Worldwide, approximately 4 million infants die within one month of their birth (the neonatal period), and one million die within their first day of life. Almost half of these neonatal deaths (1.8 million infants) are related to hypothermia before newborns have adequate body fat and metabolic rate to maintain viable body temperature. More than 50 percent of these babies are born prematurely.¹

Newborn temperature regulation has long been known to be critical to infant survival, particularly for premature babies. Kangaroo Mother Care (KMC) is the recommended

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technique for warming infants in resource poor environments by placing the child directly on the mother's chest. Although KMC has been demonstrated to reduce morbidity and mortality in low birth weight infants, its use has been limited by several factors. There is a high rate of maternal mortality during childbirth in the developing world. Of the mothers who do survive, many are unable to provide continuous KMC because they have additional responsibilities, such as manual labor and caring for other family members. In some regions, skin-to-skin contact is also culturally inappropriate and considered a violation of privacy.

Because of the high number of neonatal deaths from hypothermia as well as the limitations of KMC, the developing world needs an alternate means to keep babies warm after birth and provide them with a supportive environment in which to grow stronger.

Incubators can prevent neonatal deaths from hypothermia, shorten hospital stays, and reduce the rate of neonatal complications leading to lifelong illness and disability. From 1950 to 1998, incubators with high concentration oxygen and other advances contributed to a 75 percent decline in infant mortality rates.² However, these benefits were disproportionately realized in developed nations, particularly those in North America and Europe. Incubator use in the developing world remains limited. A major barrier to adoption is cost, with modern incubators requiring an investment up to \$30,000 or more per unit. Developing regions also frequently do not have the technical expertise and access to replacement parts needed to repair these complicated devices.

ABOUT DESIGN THAT MATTERS

Design that Matters (DtM) is a nonprofit design firm headquartered in Cambridge, Massachusetts. DtM was founded in 2001 by graduate students at the MIT Media Lab as a design studio and seminar course for students aiming to solve design problems for poor communities. Timothy Prestero and Neil Cantor committed themselves to this mission full time in 2003 and established DtM as an independent 501(c)(3) nonprofit. DtM's mission is to develop products and services that allow social enterprises in developing countries to overcome barriers to achieving scale and impact. It has established a collaborative design process that has engaged more than 700 volunteers in academia and industry to contribute their expertise. Since its inception, the organization has launched more than a dozen product concepts. DtM focuses on problems in health care, education, and clean water.

ONE CHALLENGE: DESIGNING CONTEXTUALLY APPROPRIATE PRODUCTS

Early in its history, DtM took an interest in the incubator challenge and began investigating the problem in collaboration with the Global Health Initiative at the Center for Integration of Medicine and Innovative Technology (CIMIT). What they learned, as Prestero put it, was that almost "every rural clinic in the developing world has a shack full of broken donated medical equipment."³ For example, international relief organizations donated eight incubators to Meulaboh, Indonesia, a city hard hit by the 2004 Indian Ocean tsunami. Prestero visited Meulaboh just a few years later and observed that every one of these incubators was no longer functioning. They had broken down after being subjected to the wear and tear of the rough environment, especially high humidity and voltage surges (from unreliable power sources). Meanwhile, hospital technicians were unable to understand the English repair manual. According to the Engineering

World Health Group at Duke University, up to 98 percent of medical equipment donated to developing nations is broken within five years.⁴

With this in mind, CIMIT hired DtM to design a new incubator. More than anything, Presterio emphasized, “We wanted to make a medical device that was really suited to the context of a developing country.”⁵ CIMIT also challenged the team to create a design made of parts that were already abundant in the developing world. CIMIT had observed that automobiles were one of the few technologies reliably maintained and repaired in developing regions.⁶ Even the smallest towns in the third world seemed to be able to keep their cars and trucks on the road. When vehicles broke down in these regions, the spare parts and know-how usually existed to fix them. As Presterio put it, “I don’t know where you get a replacement incubator filter in a remote Nepalese village ... but you likely can find someone there who can replace a car’s air filter. That’s where this idea really [had] virtue.”⁷ Repurposing these parts would also allow medical device manufacturers to tap into the well-established automotive supply chain.

THE SOLUTION: MATCHING DESIGN TO LOCAL SUPPLIES AND EXPERTISE

In the summer of 2007, the design team took its first steps towards better understanding the utility of car parts. They “tore apart” what Presterio called “a heaping pile of dead Toyota 4Runners, [discarding] thousands of pieces until they had things that are plentiful in rural areas” and which might be adapted to build an incubator.⁸ The design team also

studied the realities of neonatal care in resource poor settings. It visited clinics, delivery rooms, and neonatal intensive care units (NICUs) in target markets in India, Bangladesh, and Nepal.

Members conducted extensive observations and interviews with medical directors, physicians, nurses, mothers, technicians, and even hospital custodians. The design team confirmed that many incubators were broken but could not be repaired due to the inability to obtain spare parts. In rural Nepal for example, there were incubators with air filters that had not been changed in over five

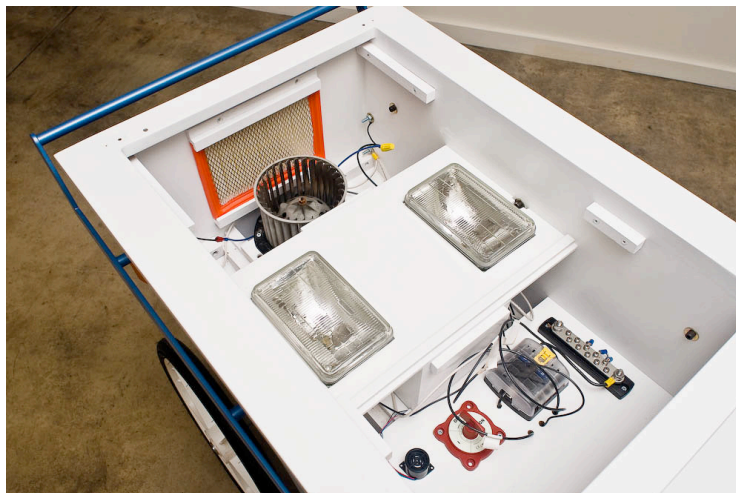
years (filters should be exchanged every six months). Even when replacement parts were available, at many hospitals there were no staff members with the appropriate technical expertise to install them. Considering all of this information, Presterio’s team then collaborated with faculty and student volunteers from MIT, the Rhode Island School of Design, Stanford, and the University of Arizona as well as with professional volunteers from IDEO and local design firms to develop its new concept incubator.⁹

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In 2010, DtM unveiled NeoNurture, a product that resembled a modern incubator on the outside but was made of automotive parts: headlights provided warming, motor blowers and dashboard fans provided filtered air for heating or cooling, and indicator lights provided alarms for health workers. NeoNurture’s design also addressed “load shedding” which occurred when power supply shortages in underdeveloped regions caused utilities to temporarily shut off electricity. This commonly led to voltage spikes that easily damaged incubators. NeoNurture was powered by motorcycle batteries, which provided both portability and protection from power surges.

From a usability perspective, NeoNurture’s bassinet could be detached from the base of the incubator to allow individuals to easily transport a newborn within the device. “The whole top of the device lifts off and has its own power supply,” Presterio explained. “One of the things we discovered in our research was that often the delivery room is on another

A peek inside the NeoNurture incubators reveals headlights and other common car parts



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er floor or in another building from the rest of the hospital. Particularly in colder temperatures, average newborns are at risk of getting fatal thermal shock as a nurse is carrying the baby in her arms from the delivery room to the NICU.” The removable bassinet could be used to overcome this problem. Similarly, he added, “It’s designed to be easy to carry up and down stairs. Few of the hospitals we visited around the world had working elevators.” The design team also built in extra storage space in the incubator’s base for sterile blankets, spare air filters, and a battery charger. The wheels were inflatable and specifically designed to survive rough terrain. “These are examples of the kinds of insights that were built into the device,” Presterio noted.

When NeoNurture went public, reactions were mixed. As Presterio recalled, “NeoNurture was designed as a concept [product]. It was designed to illustrate a series of insights about newborn care, and the car parts angle was just one of aspect. Unfortunately, it was the story that made everyone go gaga, and it’s the one that got the most press.” DtM did not complete any clinical testing of the product, but it gathered feedback from a wide cross-section of stakeholders. While caregivers generally reacted positively, the response from medical device manufacturers was more conservative. “From a manufacturer’s standpoint, it’s a nightmare,” admitted Presterio. “From their perspective, it’s a huge liability risk. Throughout the design process, the team was committed to avoiding standardization. “As soon as you say, ‘You can only use a 4Runner’s headlight,’ the value goes out the window,” he said.¹⁰ However, this decision had unintended consequences. “If you can put a headlamp to serve as a heat source in this device, who’s to say somebody’s going to put the right headlamp in there? And so from a quality control standpoint the car parts idea made people who have to worry about liability very nervous.”

According to Presterio, what got lost in the whirlwind of articles hyping the “car parts incubator” were the key insights DtM had about designing a product was not just a less expensive version of a “first world” device, but something optimized for the developing world context. “What we see too often are product adaptations for emerging markets are limited to value engineering. You take an expensive product and you make it cheap. The problem is that everybody wants inexpensive, but nobody wants cheap. Designing a product for the context is much more complicated than simply making it cheap,” he said. For example, the ratio of patients to healthcare providers in an American NICU is rough-

ly 1:1 or better, according to Prestero. However, in the developing world, a hospital might have 30 newborns per nurse. “That tells you that there are a lot of things that have to change in the way a device interacts with both the patient and the caregiver in a context where there are such extreme differences,” he said.

With the NeoNurture design, Prestero and his team were most proud of the work they completed around simplifying traditional incubator designs, reducing features, and making the user interface more intuitive. “The design also incorporated a lot of thinking about how to make a device that increases the confidence of somebody who doesn’t have the same level of training or education as an American nurse. You find a lot of brand new technologies sitting under dust cloths in hospitals overseas because nobody knows how to use them. And nobody wants to be the one to hurt a baby trying them out. So a lot of nurses are perfectly happy to leave an amazing new piece of technology that may have cost \$30,000 sitting in a closet,” he commented. NeoNurture addressed these issues while still giving users the best of what state-of-the-art incubators had to offer in terms of infant access, visibility, and the ability to support improved health outcomes.

According to the terms of their agreement, DtM turned over NeoNurture to CIMIT after its introduction. “CIMIT’s goal was to use that device as a way of communicating with medical device manufacturers. And so I know they started talking with a couple different non-US based medical device companies about adapting the product specifically, as well as adopting the design philosophy in general,” Prestero said. In parallel, DtM took the lessons from the project and has begun applying them to other products in the infant care space. Reflecting on the experience, Prestero focused on the contextually optimized design of the product: “If there’s a message that we could communicate about this project, it’s don’t focus on car parts. But also don’t focus on cost. Making something cheap is not the answer.” ♦

NOTES

- 1 Lawn et al., “Neonatal Survival 1—4 Million Neonatal Deaths: When? Where? Why?” *The Lancet*, 2005; 365: 891-900.
- 2 S. Johnson, *Where Good Ideas Come From: The Natural History of Innovation*, Riverhead (New York) 2010.
- 3 Jonathan Schultz, “A Baby Incubator Made from Car Parts,” *The New York Times*, November 23, 2010, <http://wheels.blogs.nytimes.com/2010/11/23/neonurtures-car-parts-baby-incubator/> (March 6, 2012).
- 4 R.A. Malkin, “Technologies for Clinically Relevant Physiological Measurements in Developing Countries,” *Physiological Measurement*, 2007, 28 R57-R63.
- 5 All quotations are from an interview with Timothy Prestero conducted in April 2012 unless otherwise cited.
- 6 Madeline Drexler, “Looking Under the Hood and Seeing an Incubator,” *The New York Times*, December 15, 2008, <http://www.nytimes.com/2008/12/16/health/16incubators.html?pagewanted=all> (April 11, 2012).
- 7 NeoNurture: The “Car Parts” Incubator,” *Design that Matters*, <http://designthatmatters.org/portfolio/projects/incubator/> (March 12, 2012).
- 8 Schultz, op. cit.
- 9 “NeoNurture: The “Car Parts” Incubator,” op. cit.
- 10 Ibid.