MEDICAL TECHOLOGY IN CONTEXT: MATERNAL AND CHILD HEALTH TECHNOLOGY AT GHANA'S CAPE COAST TEACHING HOSPITAL

by

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This thesis draws on ethnography and science and technology studies to consider the use of medical technology within the context of Cape Coast Teaching Hospital in southern Ghana. All too often the transfer and integration of medical technologies to the global south are based on the simplistic assumption that the advantages of foreign technology are self-evident and universal. However, this thesis presents evidence against the idea that medical technology remains static as it travels to different healthcare contexts. Through ethnographic observation and analysis, I explore how medical technology in Cape Coast Teaching Hospital (CCTH) has the capacity to change the dynamics of the clinical space while also being changed by the health staff, patients, and families with which they interact. To demonstrate this phenomenon, I investigate three medical technologies involved in maternal and newborn health at CCTH. I show how the ultrasound machine, pulse oximeter, and neonatal incubator, change in this context to fit the needs of health professionals and patients while also working to change the way people relate to each other and their illnesses. Through exploration of these three concrete examples of medical technology within maternal and child health, this thesis shows that context matters in how medical technology operates and is operated within the clinical space. This awareness of medical technology in context pushes for a change in international politics and ideologies surrounding global health.

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Introduction: Akwaaba and the Hum of the Hospital

Preface

Transfer of technology in all spaces, but especially of biomedical equipment, is often indiscriminately characterized as a positive product of globalization and international aid. Inserting foreign medical technologies into the clinical spaces of the global south is expected to lead directly to health equity. The export of medical technologies to the global south is based on the simplistic assumption that the advantages of foreign technology are self-evident and universal. Medical technology granted this power is presumed to be fit for all, a universal lifesaver, a product of advanced scientific knowledge with the ability to transcend cultures to improve health and wellbeing around the world. This comes with the assumption that medical technology remains static as it transverses borders, that it retains its original purpose and meaning as it moves through cultures.

However, this thesis interrogates the idea of the global movement of technology as an unalloyed good. This thesis considers the ideologies, assumptions, and expectations that travel with the medical equipment in order to question the characterization of medical technology as a static source of health care. Exploration of foreign medical devices in a unique clinical context reveals that medical technology can have influence beyond the expected clinical effects. Awareness of the way context matters for the way medical technology is experienced by doctors, nurses, students, and patients calls for the reconsideration of the current methods of technology transfer as global health aid.

Cape Coast, Ghana

The rain falls heavy and slow as if the drops are getting stuck in the inky black of the night. It sounds like thunder and smells like home. When the sun rises, the morning is cast in scorching heat that dries the red dirt roads into frozen rivers. I step in footprints of dried mud as I walk alongside the busy main road towards Cape Coast Teaching Hospital. Children in matching school uniforms chase a chicken out from its shady spot under a car frame. The music that drifts out of open taxi windows seems to get caught up in the wind to rustle the palm fronds above me. A woman crosses the street with a full bucket of water balanced on her head and a sleeping baby on her back. I turn at the corner by the roasted corn stand, and the sprawling, green trimmed buildings of the Cape Coast Teaching Hospital come into view. As I walk up the graveled driveway toward the entrance, I can almost feel the building humming. It hums a tune so different than the reprise of street noises behind me.

The one-story hospital wards are linked by a breezeway with a floor worn so smooth it reflects the sun. Outside each ward, families gather in the grass under bold red signs for Female Surgery, Maternity, Labor and Delivery, Paediatrics. The people sitting in the plastic chairs and leaning against the wall of the open-air waiting room are there six hours later when I leave for the day. Hospital gowns and sheets are washed in tubs by the patients' families and laid out in the sun to dry. The breeze funnels down the hallway, blowing the noise of the waiting area across the rainbow of baby clothes hung on a clothesline. A group of young medical students, white coats gleaming, walk out of the Paediatrics ward. I hold the door to the ward open as a man carries a toddler with a full leg cast inside. I let the door swing closed behind me and it takes a second for my

eyes to adjust to the sudden lack of sunlight. Hope, a medical student I met on my first day here greets me, “akwaaba, eti sen [welcome, how are you]”, before shaking my hand. Our handshake is broken in the typical Ghanaian way as our thumbs and middle fingers snap together.

I spent the summer of 2017 in Cape Coast, Ghana, shadowing doctors, medical students and nurses in the Female Surgery, Labor and Delivery, and Paediatrics wards of Cape Coast Teaching Hospital (CCTH). I had the privilege to learn about what it means to care for patients and their families in the face of scarce resources and understaffing. I had the opportunity to see medicine operate in a context strikingly different from that which I was familiar. I was welcomed into a group of medical and nursing students learning to be healthcare providers in an environment that was constantly pushing back at them. I witnessed medicine working in a way that made me realize biomedical science is not a neutral body of knowledge. Compared to my experiences clinically shadowing in Oregon, I saw that the role of medical knowledge and technology is not universal; it does not remain static as it travels the world.

In Oregon, I was used to seeing medical technology at the center of every doctor-patient interaction: the pediatrician squinting at the electronic patient chart, the heart-lung machine spinning in the middle of the operating room, the neonatal incubators with their spider webs of wires. In Oregon, these devices always functioned flawlessly as expected pieces of the clinical landscape. I always found myself fascinated by these innovative medical devices, only seeing their ability to improve the productivity and availability of healthcare. But my experience in Ghana made me consider how these medical devices function within the global health framework. What

happens when medical technology designed and first used in the global north is transferred internationally to different healthcare systems? How does medical technology affect existing health care arrangements and relationships and in turn how is it affected by them? How is this medical technology adapted and appropriated within this new context? What does this process say about global health aid and the relationship between the global north and south?

Chapter 1: Background

The Impossibility of Neutral Health Science

Biomedical knowledge is translated into different languages and guided across borders to be shared, but the translation is expected to be transparent, the information communicated is assumed to be universal. This idea of neutral science pervades all aspects of the healthcare field. Medical competence is understood as the ability to see past the individual patient's subjectivity to get at the underlying physiological problems that will lead to diagnoses and treatment. Health professions students are instructed to take on an objective view of medicine, to not let their patient interactions be affected by social class, race, sexuality, or gender. In this vein, many claim medical technology is "scientific and beyond culture, and is thus eminently portable."[1] Medical technology is expected to be transferable, to be placed in a foreign healthcare system to carry out the diagnostic or therapeutic actions for which it was designed. Cultural barriers may require altering of a given machine or technique, but the technology itself is neutral, its purpose, methods and effects are expected to be static in all locations.

However, this portrayal of medical technology as a neutral force is not widely accepted with the fields of medical anthropology or STS. Biomedicine in anthropology is understood "in terms of experience and perception, performance and practice, power relations and local biologies."[2] Joseph Rouse, a philosopher of science and society,

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[1] Claire Wendland, *A Heart for the Work: Journeys Through an African Medical School* (Chicago: University of Chicago Press, 2010), 7.

[2] Bernhard Hadolt, Viola Hörbst, and Babette Müller-Rockstroh, "Biomedical Techniques in Context: On the Appropriation of Biomedical Procedures and Artifacts" *Medical Anthropology*, 31:3 (2012): 180, DOI: 10.1080/01459740.2011.636410.

argues for an analysis of science that acknowledges that "the traffic across the boundaries erected between science and society is always two-way."[3] The questions we ask in science, how we apply them, who applies them, which results are circulated, are all questions that require exchanges between science and society. In health science, this inseparable tie between knowledge and culture becomes even more evident. As medical anthropologist Claire Wendland explains, "because medical science is so thoroughly embodied, learned, and practiced on the real bodies of real people, it has been more difficult to maintain the illusion that biomedical knowledge is culture free and disembodied."[4] In the clinical setting, science is charged with the values, theories, practices and social institutions of its Western origin.[5] As health science travels, it comes into contact with contextual aspects of other cultures to cause effects beyond the expected clinical outcomes.

Medical Technology Travels

In this increasingly globalized world, one of the most observable ways biomedicine is transferred is through the movement of medical technology. The WHO summarizes medical technology as "an instrument, apparatus or machine that is used in the prevention, diagnosis or treatment of illness or disease, or for detecting, measuring, restoring, correcting or modifying the structure or function of the body for some health

[3] Joseph Rouse, "What Are Cultural Studies of Scientific Knowledge?" *Configurations* 1, no 1 (1993): 4, doi:10.1353/con.1993.0006.
[4] Wendland, *A Heart for the Work,* 8.
[5] Andrew Cunningham and Birdie Andrews, *Western Medicine as Contested Knowledge* (New York: Manchester University Press, 1997), 11.

purpose."[6] However, in anthropological terms, medical technologies are "fundamental elements of individual and collective attempts to order lives and bodies in health and sickness."[7] In a clinical setting, medical technology is embedded with the ways we see the human body, express and evaluate illnesses, and interact with patients and health professionals. With this understanding, the transfer of medical technology also means the transfer of social institutions and foreign perceptions of disease. Along with medical equipment's physical pieces and instruction manuals comes the western idea that all diseases are manageable with modern medical solutions and that reasonableness can only be established through scientific means.[8] With the transfer of medical technology consideration is overwhelmingly given to the receiving facility's infrastructure, maintenance, and management. Little consideration is given as to how the purpose of the technology, who uses it, and how it is used changes from location to location and how this might affect the local healthcare system.

The export of medical equipment to the global south has the power to act on the public healthcare sector on a grand scheme. Infiltration of foreign biomedical technology into nations of the global south has been argued as a source of cultural imperialism as the market of the global north works to extend dominant power positions. Biomedicine has also been shown to aggravate socioeconomic inequalities, diminish primary care infrastructure, and overshadow the role of structural violence and

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[6] World Health Organization, *Medical Devices : Managing the Mismatch* (Geneva, World Health Organization, 2010), 2.
[7] Hadolt, Biomedical Techniques in Context, 179.
[8] Siegrid Tautz et al, "Between Fear and Relief: How Rural Pregnant Women Experience Foetal Ultrasound in a Botswana District Hospital," Social Science and Medicine 50 (2000): 692.

vulnerabilities in health. Fabricating medical technology as culturally neutral allows markets of the global north to more readily trade, sell, and export their products. It is critical to highlight that whether viewed as neutral or culturally charged, medical technologies are always seen as products in export, artifacts of scientific knowledge that must travel over both physical and ideological distances to reach countries of the global south.

Medical technology in export to the global south also has a critical influence on a more focused scale within the healthcare context. Studies in STS and medical anthropology have explored how medical technology can be and do different things in different clinical contexts. Medical anthropologists argue that medical technology "should be studied as subject to and part of the processes of sociocultural adaptation and appropriation in different societal settings."[9] Medical technology is invented and built to help health professionals diagnose and treat patients with more efficiency and accuracy. It is designed to show off the most recent scientific achievements in protecting and sustaining the human body. Medical technology is exported to improve health statistics, to turn a profit, to save lives and stop the spread of disease.[10] However in clinical settings of the global south, where conditions are harsh, resources limited, and culture dynamic, medical equipment can play a variety of roles as science and society constantly intersect. In this process, neither medical technology nor its new context remain unaffected. As technologies are exported to diverse locations, they alter

[9] Hadolt, Biomedical Techniques in Context, 181.
[10] Babette Müller-Rockstroh, "Appropriate and Appropriated Technology: Lessons Learned from Ultrasound in Tanzania," Medical Anthropology 31, no. 3 (May 2012): 198. doi:10.1080/01459740.2011.639105.

existing practices, identities, and institutional structures. At the same time, these technologies are shaped by the political, economic, and sociocultural forces of the local context.[11] This process of mutual shaping that comes with the movement of medical technology is a critical element that is often overlooked in global health policy. More research is needed regarding the underlying social, cultural, and institutional context of where the technology originated and where it will operate after export.

"Appropriate Technology" for Developing Nations

In discussing the dynamic role of medical technologies, it is critical to consider how these technologies arrive in Ghana and other countries of the global south alongside the idea of "appropriate technology for developing nations".[12] Appropriate technology can be used as a term that portrays the global south as underdeveloped, inferior, and in need of low tech, less complex devices. The "appropriate" medical technology that travels from the global north to Ghana is often determined by conceptualizations that portray the country as impoverished, uneducated, and in desperate need of outside expertise. As a result, aid agencies and medical technology manufacturers often promote the transfer of technology that is inexpensive, less advanced, outdated, and basic.

According to the WHO, "appropriate technology" for developing countries includes equipment that is, "inexpensive, portable, and solidly constructed."[13] In 2015,

[11] Hadolt, Biomedical Techniques in Context, 180.

[12] World Health Organization, *Medical Devices: Managing the Mismatch* (Geneva, World Health Organization, 2010), 11.
[13] Ibid., 11.

the WHO along with UNFPA, UNICEF, and the World Bank updated their collaborative working publication "Interagency List of Priority Medical Devices for Essential Interventions for Reproductive, Maternal, Newborn and Child Health."[14] This document was developed in Denmark and Switzerland by the heads of these four aid agencies based on review of their own previous publications. In one of these publications reviewed, titled "Medical Devices: Managing the Mismatch", the WHO outlined the medical device agenda with the "crucial 4 As: Availability, Accessibility, Appropriateness, and Affordability."[15] Consistent with the common perspective of Africa's condition, international experts see the solution as one of a technological embrace that comes with globalization and leads to improved measurable health outcomes. This push for a global embrace of medical technology comes with the idea that medical technology is "fit for all", that medical technology is the universal solution.[16]

With the WHO definition of appropriate technology, medical technology in export becomes an object of aid; an object that carries with it the idea that African countries need a helping hand from the West. Müller-Rockstroh notes this dynamic, aptly writing, "Africa's rebirth, international reports imply, now requires donors as midwives and Africa to do the labor."[17] Underlying this perspective of the power of medical technology is a goal toward further globalization that will come when African

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[14] World Health Organization, "Interagency List of Medical Devices for Essential Interventions for Reproductive, Maternal, Newborn and Child Health," (Geneva, World Health Organization, 2015).
[15] World Health Organization, *Medical Devices: Managing the Mismatch*, 23.
[16] Ibid., 15.
[17] Babette Müller-Rockstroh, "Appropriate and Appropriated Technology: Lessons Learned from Ultrasound in Tanzania," *Medical Anthropology* 31, no. 3 (May 2012): 201. doi:10.1080/01459740.2011.639105.

countries follow the path laid out for them by wealthier nations. This form of development seems to require the packaging of Africa and its people into neat images and statistics to be placed in front of biotechnical researchers, international policy makers, and technology companies.

However, the term appropriate technology can also be a phrase used when the local context and underlying determinants of health are thoughtfully considered before integrating a device as suitable. For medical anthropologist Paul Famer, a model of appropriate technology is one that is founded on understandings of local history, culture and social institutions, and community desires. For Farmer, appropriate technology should be used as a term that empowers the local community by considering underlying determinants of health as well as serving the already sick. With this perspective of appropriate technology, the global south should have medical technology that best addresses the causes of morbidity and mortality, not technology that is the cheapest or most cost effective. Many models advanced in the global development field are founded on the idea that there are only limited funds available so that projects must choose between high technology interventions or preventative services. And in Famer's view, the term appropriate technology used by large global development institutions is a "means of justifying the unfair partition of the world's wealth."[18]

[18] Farmer, Paul. *Infections and Inequalities: The Modern Plagues*. Berkeley : University of California Press, 1999.

Medical technology's path to Cape Coast, Ghana

Ghana has become a major market for and recipient of foreign medical technologies. The perception that technology is the only right avenue towards better public health and therefore toward further development is not only readily accepted by the public, but attractive to international donors, technology companies, and national governments. As a public government owned referral and teaching facility, Cape Coast Teaching hospital is financed and supplied through the Ghana Ministry of Health, internally generated funds, and donations. Placed within clinical settings, medical equipment is expected to work toward quick, visible improvements in the public health sector, which is appealing to the Ministry of Health (MOH). Medical equipment's path to the ward floors of Cape Coast Teaching Hospital can be considered across three main categories: internally generated funds used for purchase by the state, international donor funding for specific programs, and private physical donations of perceived needed equipment.

Ghana Ministry of Health Technology Purchase

The Ghanaian national health budget for medical technology is made up of state funds as well international aid. For health technology companies, Ghana can be seen as a paradoxical market. Ghana can be considered risky for business in regards to maintenance, communication, payments, and operating skill. But at the same time, Ghana is a vastly open market with huge potential due to the massive need for improved health services. The globalized view of medical technology as the modern element of public health has influenced how countries allocate health sector funds.

Just after I arrived in Cape Coast, the Ministry of Health had finished a national campaign centered on maternal and child health. For CCTH, this involved developing and equipping an Obstetrics and Gynecology Emergency block. A ceremony was held to commemorate the opening of this section of the Accident and Emergency ward. Green and yellow ribbons were stretched across a newly purchased ultrasound machine that was nestled between two hospital beds. The ribbons were cut after a speech about how the ultrasound machine will encourage more mothers to come to the hospital to give birth and allow emergency personnel to better direct expectant mothers to other wards of the hospital.

Over the past 10 years, Ghana Health Service (GHS) annual reports show that increasing amount of health budget funds have been allocated towards the purchase and maintenance of medical equipment. And in 2014, the GHS developed the Equipment Maintenance Fund for "maintenance and replacement of medical equipment."[19] Before I began shadowing, I met with the deputy director of administration to discuss in which wards I would like to shadow. With every other description of a ward, the deputy director proudly announced different types of equipment the hospital had purchased: the hemodialysis machines in the dialysis unit, the new infant incubator in the pediatrics ward. The attractiveness of each ward seemed to be based partly on the equipment operating on the floor.

This increased purchase of medical equipment does not come without disadvantages and barriers. The MOH does not always closely consider individual hospital needs when allocating the health budget and using international aid often

[19] Ghana Health Service, "Ghana Health Service 2014 Annual Report." *GHANA 1*, 2015, 42.

comes with predetermined conditions. The purchase of medical equipment from wealthy countries by countries of the global south often requires loans tied to structural adjustment programs or other outlined conditions that can further promote the imperialistic relationship between donor and receiving country. In an introductory address of a 2016 annual report, the GHS writes, "the inability to address issues of inadequate financing and the pattern of erratic fund flow over successive years is hampering service delivery efforts [….] the majority of donated funds were earmarked for implementing only particular programmes."[20] In this way, health and development becomes dependent on material conditions that amplify relations of power and production.

Donations from Health Technology Companies

In addition to the national monetary budget for medical technology, large physical donations come from outside sources. These sources include NGO's, international aid agencies, and medical equipment companies. While well intentioned, these international donations of equipment can siphon authority away from the national health systems. When medical equipment is donated, the local authorities often have little say over where the equipment goes and who operates it. This often means there is less of a foundation, such as trained operators and maintenance strategies, to support the equipment. Another idea to consider is that these physical donations are often restricted by specific conditions the local health system is expected to follow.

[20] Ghana Health Service, "Ghana Health Service 2016 Annual Report," 2017.

For example, in a few months before my arrival in Cape Coast, Midwex, a communication and medical technology company based in the United Arab Emirates, donated CCTH's first digital X-ray machine. In an article published by a Ghana news source, the hospital's board director is seen smiling next to the Midwex Managing Director, a poster in the background advertising Midwex as "Your technology partner in Africa". In an article published by Midwex regarding this donation, it is mentioned that the X-ray was donated on the condition that CCTH purchase "a certain quantity of consumables" from Midwex. [21] By the time I arrived in Cape Coast in July, the machine was out of service due to inadequate replacement parts.

Additionally, the location and type of equipment donation from large companies is constricted by loan and insurance agreements that make the donation possible. An example of this can be outlined in the ultrasound transfer project Philips Medical Systems started with Ghana in 1996. Due to the large market potential, but high risk in terms of secure payment, Philips Medical Systems enrolled in a financing program with the Dutch Investment Bank. The Bank granted the necessary budget and helped develop an insured loan to protect the company if payment was delayed or could not be made. However, conditions existed within this agreement that limited the designs of medical technology and type of health facility to which these technologies could be placed. Philips Medical Systems' has maintained a presence in Ghana and other African counties today with the company's annual flagship "Cairo to Cape Town Roadshow", of which Accra, Ghana is the sixth stop. In an advertisement published in *The Herald Ghana* the event focuses on two key challenges facing Africa today, one of which is

[21] Amiroune, Khalil. "Our First X-Ray Project in Ghana." *Midwex*, 2018.

"the revitalization of African healthcare infrastructure" which Philips contributed to with their brand new VISIQ ultra-mobile ultrasound device that plugs into tablets, a device not very common in public hospitals.[22] Overall, donations from large companies and international aid organizations can prevent the local health administrations from having authority over what and how medical technology is implemented.

Equipment donations from local and international health organizations

Medical technology also ends up on the ward floors of CCTH through private philanthropic donation. In the Labor and Delivery, and Paediatrics wards, donations received in the past few years included neonatal incubators, rapid diagnostic tests, a defibrillator, and an oxygen concentrator. Sources of these donations to CCTH include local philanthropies, US medical schools, individual traveling doctors and foreign volunteers. Despite well-intentions, the context within which the medical technology operates is often overlooked in this donation process. These donations of medical devices often come without service contracts for maintenance and repair. The device might have certain operating requirements such as a specific electricity voltage or continuous source of oxygen that cannot be supplied with the hospital. As a result, many private equipment donations break down or never come to function as prescribed in the clinical setting. The presence of broken or out of service technology, even though it cannot function as prescribed, is still involved in the mutual shaping between health technology and clinical context.

[22] "PHILIPS Advances Quality Healthcare in Ghana." *The Herald Ghana*. July 2014.

For example, the University of Utah donated two neonatal incubators to CCTH, a seemingly fitting donation for a hospital working to expand its newborn ICU services. However, the incubators had voltage requirements above what the hospital's power grid ever reached. These incubators were never powered on within the walls of CCTH. Instead, they were pushed into the corner of the NICU, their plastic covers removed to be used as linen storage and spare parts for other incubators.

While medical equipment and monetary donations are given with the intent to strengthen the local health system, the local context of the receiving setting is often left unconsidered. The majority of medical technology is designed to operate where there is stable electricity, and amenities such as purified water and pressured gas, which are not always available at CCTH. The majority of medical technology is also designed to operate within the cultural and social institutions of the global north. But what happens when the medical technology is placed in a drastically different context?

Chapter 2: Methods

In this research, this new context is Cape Coast Teaching Hospital in Ghana. This thesis is based on ethnographic field notes recorded while clinical shadowing at Cape Coast Teaching Hospital paired with years of shadowing experience in Oregon. Cape Coast Teaching Hospital (CCTH) is a 400 bed capacity referral hospital serving the Central region and bordering parts of the neighboring regions. The hospital was established by the Ministry of Health in 1998 and was transformed into a teaching hospital in 2013. CCTH is a teaching facility for medical students from the University of Cape Coast as well as a large population of nursing students. CCTH provides a comprehensive range of services including general inpatient and outpatient services within each ward, a pharmacy, physical therapy clinic, dialysis center, imaging center, laboratory, and public health outreach program.

While in Cape Coast, I shadowed health professionals and students in the Female Surgery, Paediatrics, and Maternity wards four days a week for a month. I was at the hospital for 5 or 6 hours during the day and also shadowed during two night shifts. As an undergraduate student, I did not perform any medical procedures or offer patient instructions; my presence on the ward floor was purely observational. However, it is critical to point out that as a foreign student on the ward floor, I affected the clinical space. Just as medical technology cannot be neutral, nor can another person's presence, something that will be discussed later.

Shadowing in my case meant accompanying doctors, nurses, and students as they went about their daily job tasks. I wore hospital scrubs and introduced myself as a university student from the United States. I followed doctors during bedside morning

rounds, during which doctors would present a patient and ask questions of the small group of medical students accompanying him (I did not shadow or meet any female doctors during my time in Ghana). In the afternoons, I spent most of my time with Ghanaian nursing and medical students, the only health care staff, besides one charge nurse, left to care for patients on the ward floor after the doctors left. During this time, the nursing and medical students graciously welcomed me into their daily activities. The medical students were mostly third and fourth year students from Cape Coast University at the hospital for their clinical training. The nursing students I interacted with ranged from 1 year to 3 years of training and were preparing for their yearly exams. I watched these students adeptly adjust what they had learned in the classroom and in training to the clinical world to essentially run the ward on their own. They improvised with insufficient resources, using plastic water bottles full of honey as antibiotic solution and cutting open intravenous saline bags to have sterile liquid to clean wounds. They timed each other's patient history checklists and tested each other on protocol. They took vitals by hand every few hours and never panicked when the power cut out.

I did not travel to Ghana with humanitarian intentions. As an undergraduate student who has taken global health classes and experienced volunteering abroad in other countries, I understood that at my level of education, I was not traveling to Cape Coast to volunteer any services in the clinical setting. However, I do acknowledge that the conversation surrounding suggested clinical experience for medical school admissions contributed to my desire to travel abroad. I was also curious to see medicine when it was stripped to its core, when it could not hide behind electronic patient charts,

beeping technology, and sterile white walls. I wanted to see medical knowledge and patient care in a different context. I felt ignorant only knowing one side, one story of how scientific knowledge translates into patient care and wellbeing. How did the topics I learned about in my global health and human physiology classes apply somewhere else?

It is also important to point out that I did not travel to Ghana with the intention of collecting fieldnotes for my thesis. I kept a detailed journal to record my experience, but at the time, it was purely for personal reasons. Shadowing domestically in Oregon sparked my interest in medical technology and the clinical observations I recorded in my journal during my time in Cape Coast emphasized medical technology in this new space. After I returned home and returned to my global health classes, I wanted to further explore medical technology in the Ghana, something I had naively thought would be unremarkable in this setting.

Originally, I planned to perform a more quantitative analysis of medical technology in Ghana, its unequal national distribution and its effects on maternal and child health statistics. However, in discussion with my advisor and with further immersion in my global health classes, I came to understand that my field notes could tell a different story. My field notes contained ethnographies of teaching, ingenuity, care, and loss within the clinical space. I recorded stories of doctors, students, patients, and caregivers interacting with each other and technology, cases when the absence of a technology changed these relationships, when the presence of the technology mediated the meaning of medicine.

In my global health courses, we had explored how biomedical science is something that comes tied to the ideology and culture of the west and assumes its power to be universal. Looking back on my shadowing experiences in Oregon and field notes from Cape Coast, I was able to tie this idea of medicine as a charged force to how I observed medical technology operating in Cape Coast compared to Oregon. My journal entries from Ghana became the materials on which I performed a content analysis, supplemented with my own recollections. I returned to my field notes regularly throughout the writing process, re-reading and analyzing the manner in which I chose to write my observations. While I did not have physical field notes from my shadowing experiences in Oregon, I was able to use my years of experience in this context to outline how medical technology functioned in this setting of the global north.

I chose to discuss the fetal ultrasound, pulse oximeter, and infant incubator in particular in this paper because they are the technologies I observed the clinical staff and patients interacting with the most on a daily basis. These three technologies were the technologies I was most able to see gain alternative meaning and purpose within this context. My familiarity with the manner in which these technologies function in the hospitals and clinics in Oregon also contributed to my decision to focus on them. Observing these technologies I thought I was so familiar with in this new context of Cape Coast pushed me to reconsider the power of medical technology within the clinical world as well as in social and political spheres. I chose these technologies for the way I observed them not only playing direct roles in diagnoses and treatment, but also affecting the way health professionals interacted with their patients and people of the community and how patients came to view their conditions.

In discussing research methods, it is important to consider to what degree my presence as a clinical shadow was observational. With my white skin, lack of local language, and blonde hair, it was obvious that I could never be just a "shadow" in the hospital. My presence in the examination room and on the ward floor altered the way clinicians treated their patients and each other as well as the way patients interacted with clinicians in ways I observed and ways I could only imagine. My presence on the ward floor might have disrupted communication between health workers, local students, and patients. I could tell doctors and patients were distracted by me, asking questions about me as someone that did not belong. Sometimes during rounds, doctors ignored local Ghanaian students to turn to me or another foreign student to answer a question. Patients might have felt their privacy had been invaded or that they did not have the authority to question my presence.

This topic of the danger of medical voluntourism and shadowing abroad is beyond the scope of this paper, but I am aware of its need to be addressed. Medical voluntourism has become increasingly popular in the United States as medical schools look for clinical experience from their applicants. But why are these students driven to travel to the global south? Students who participate in international clinical experiences report a broadened global perspective, an appreciation for cultural influences on health and a growing awareness of the social determinants of health, alongside their misguided sense of helping others.[23] Although US Department of Justice's guidelines limit undergraduate patient interaction abroad to the same level of interaction they would

[23] Irmgard Bauer, "More Harm than Good? The Questionable Ethics of Medical Volunteering and International Student Placements," *Tropical Diseases, Travel Medicine and Vaccines* 3 (2017): 5. doi:10.1186/s40794-017-0048-y.

have as volunteers in the US, many students share the common story of performing clinical tasks that would never be allowed in domestic settings. As director of Child Family Health International, Jessica Evert writes, "in the name of 'helping' and 'learning', students are undertaking activities that put patients, the student, as well as sending and receiving organizations, in jeopardy."[24]

Many untrained students are driven by the idea that in poor countries, any level of medical care is better than nothing. This perspective is dangerous, disruptive, and imperialistic. Students traveling abroad for hands on patient care is "unprofessional and goes against the very social justice principles that concerned students and enabling organizations purportedly aim to address."[25] Allowing unqualified volunteers or even culturally ignorant medical professionals to practice medical procedures on vulnerable populations can lead to physical harm and the need for further treatment after complications. This type of volunteering is a product of structural constraints, vulnerabilities, and relationships between nations that are "overlaid by notions of superiority and inferiority, of developed and undeveloped."[26] The idea that even unqualified, short-term help is desirable in the current situation further promotes the idea that countries of the global south are always in need of aid, that they are recipients, not generators of health and technology expertise. Students are most often motivated by a type of naive compassion, but their very presence and the work they carry out has

[24] Evert, Jessica, Tricia Todd, and Peggy Zitek,"Do You GASP ? How Pre-Health Students Delivering Babies in Africa Is Quickly Becoming Consequentially Unacceptable," *The Advisor*, no. December (2015): 61.
[25] Jessica Evert et al., "Do You GASP ? How Pre-Health Students Delivering Babies in Africa Is Quickly Becoming Consequentially Unacceptable," 61.
[26] H.L Perold et al, "The Colonial Legacy of International Voluntary Service," *Community Development Journal* 48, no. 2 (April 2013): 182. doi:10.1093/cdj/bss037.

unintended consequences. The movement of health technology can be analyzed in this same vein as it becomes an object of aid that can be and do more than was originally expected in clinical settings.

In this paper, I will add to the conversation of medical technology in global contexts that is pushing to change international politics surrounding global health. Through ethnographic observation, I will explore how medical technology in Cape Coast Teaching Hospital (CCTH) has the capacity to change the dynamics of the clinical space while also being changed by the health staff, patients, and families with which they interact. To demonstrate this phenomenon, I investigate three medical technologies involved in maternal and newborn health at CCTH. I show how the ultrasound machine, pulse oximeter, and neonatal incubator, change in this context to fit the needs of health professionals and patients while also working to change the way people relate to each other and their illnesses. Through exploration of these three concrete examples of medical technology within maternal and child health, I show that context matters in how medical technology operates and is operated within the clinical space.

Chapter 3: The Fetal Ultrasound

Oregon, United States

The lights are dimmed and soft music plays from speakers in the ceiling of the hallway. The couple is met by an ultrasound technician in bubble gum pink scrubs. She chats with the couple as she ushers them into the room illuminated by the glowing screen of the ultrasound machine's monitor. The expectant mother lies down on the examination table, the white paper crinkling under her as she makes small talk with the technician. The technician squirts clear gel over her belly, moves the transducer device across her abdomen, taps on the keyboard, and a grey and white blur appears on the screen. The technician asks questions from the mother, how's your pregnancy going so far, any discomfort or concerns. While the woman responds, the technician silently assesses the fetal echo on the monitor to check for any abnormalities. Only then does she swivel the monitor screen so that the couple can see. She congratulates the couple on their first baby, pointing out the head, beating heart, and "ten tiny cute toes" before printing out copies of "baby's first picture" for the couple to take home. The father mentions that the baby has his nose as the technician turns the monitor back to examine the fetus from the head down to toes, taking measurements of bone growth, noting anatomical landmarks, and estimating amniotic fluid volume.

Cape Coast, Ghana

She tells the young medical student that she has been nauseous, bleeding, and having stomach pains since last night. She has been sitting in a plastic chair in the

waiting area for hours, sweating and watching people come and go. She is shown to a metal examination table behind privacy screens where a nurse palpates her abdomen, asking her where the pain is centered. Her physical symptoms along with her medical history, leads the nurse to suspect a ruptured ectopic pregnancy. The nurse hands the women a pink card and tells her she needs to "get a video done" as she motions her in the general direction of the imaging room. A nursing student takes the women's elbow, walking her across the breezeway to join a line of women in varying stages of pregnancy waiting outside. Finally, it is her turn as the nursing student leads her inside, telling her she must change clothing and lay completely still. The woman lies down before a nurse prepares her for the ultrasound. The doctor walks over to greet the women, and begins the examination, his eyes focused on the monitor screen in front of him. The woman stares up at the ceiling as the doctor concludes his silent examination by writing on the pink card.

Technology Overview

For decades, health professionals in the global north have regarded ultrasound as the "most important antepartum diagnostic technique available."[27] It is a popular, non-invasive technique that uses ultrasound waves to create images of the fetus and intrauterine environment. Ultrasound imaging can reveal fetal anatomy, growth and development, pathologies, sex, and activity patterns. By emitting and receiving high frequency sound waves across tissues, the machine's transducer is able to generate a continuous stream of images that show up on the machine's screen. The sound waves

[27] Lisa Mitchell, Baby's First Picture: Ultrasound and the Politics of Fetal Subjects (Toronto: University of Toronto Press, 2001), 4.

travel until they hit a boundary between tissue types, like between soft tissue and bone, at which point they are reflected back to the transducer. The different speed of deflection and reception of the ultrasound waves show up as different gray scale colors depending on the different densities of body tissues. Bones of the skull and legs reflect the waves at different intensities than soft tissues like organs and fat or fluid. The reflected waves are picked up by the transducer and relayed to the machine which calculates the distance and intensities of the echoed signals to form a two dimensional image.[28] Since this technology was first developed in the 1950s, it has become a routine and expected aspect of prenatal care for millions of expectant mothers in the global north. In the United States, women have up to five ultrasounds during their pregnancy.[29]

As ultrasound scans have become a standard feature of maternal health services in countries of the global north, its purpose has moved beyond the medical context. Ultrasound's diagnostic images are not just a technical matter, they are socially and culturally constructed to have a variety of meanings. Ultrasound images "are highly ambiguous and must be interpreted" by trained sonographers." [30] Studies have revealed that most expectant couples cannot recognize early fetal anatomy on the ultrasound image without the sonographer's interpretation and explanation. Despite the fact that many parents cannot interpret the little grey blur of the ultrasound image, the technology is emotionally compelling and firmly lodged in Western culture to say a lot about the fetus as a person. Clinicians use ultrasound as a means to observe and assess

[28] S Campbell, "A Short History of Sonography in Obstetrics and Gynaecology," *Facts, Views & Vision in ObGyn* 5, no. 3 (2013): 215. http://www.ncbi.nlm.nih.gov/pubmed/24753947.
[29] Mitchel, *Baby's First Picture,* 7.
[30] Ibid., 6.

fetal development, age, and position. When these clinical assessments are then translated into laymen's terms for the parents, ultrasound has the ability to transform the fetus into a socially meaningful being. Mitchel captures the hybrid capabilities of ultrasound, writing, "as sonographers search for the very anomalies that may suspend or constrain fetal personhood, they are constructing that personhood by talking about the image and encouraging parents to see and to bond with a sentient and acting 'baby'".[31] Ultrasound is also thought to stimulate the parents' emotional bond to the fetus and reduce anxiety. In this way, the technology influences women into complying with prenatal care recommendations.[32]

Ultrasound technology is becoming increasingly popular in the global south due to its diagnostic capabilities and promotion as appropriate technology by international donors and aid organizations. In 1985, the WHO presented policy advocating for ultrasound as a technology "fit for all" that should be disseminated to primary health care facilities.[33] Transfer of ultrasound technology to nations characterized by high child and maternal mortality rates became a critical aspect of international commitment to the Millennium Development Goals. However, in Ghana, ultrasound's mode of transfer turned it into an exclusive object of maternal health. In the 1980s, ultrasound machines traveled to Ghana in the luggage of white medical missionaries who worked in private mission hospitals in rural areas. Therefore, the majority of health professionals working in public sector state hospitals "encountered ultrasound either as

[31] Mitchel, *Baby's First Picture,* 118.
[32] Ibid., 4.
[33] Kurjak, A, and B Breyer. "The Use of Ultrasound in Developing Countries." *Ultrasound in Medicine & Biology* 12, no. 8 (August 1986): 611–21. http://www.ncbi.nlm.nih.gov/pubmed/3532475.

merely hear-say or in written form in their British textbooks."[34] This unequal distribution of ultrasound technology between private and public health care centers became one of many contributing factors leading to the emigration of health professionals and patients from public to private health care.[35] Despite the Ministry of Health's campaigns to purchase more maternal health equipment for public hospitals, the unequal pattern of distribution remains today.

The transfer policies that historically sought and continue to seek to export ultrasound to Ghana as a means to improve maternal and newborn health statistics often fail to consider ultrasound technology in context. Instead, policies view the technology and the context in isolation. According to the WHO, once the issues of cost and sustainable supply are resolved, the ultrasound has the universal capacity to significantly improve maternal health.[36] Viewing the transfer of ultrasound technology as a neutral object of aid overlooks the possible consequences and appropriations that can arise within the local clinical environment as a result of new technology placement. The ultrasound machine is experienced differently than its counterpart in America by the health professionals, medical and nursing students, and pregnant women of CCTH. Within the maternity block (labor and delivery and antenatal wards) ultrasound technology changes and is changed by the local clinical context of CCTH.

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[34] Müller-Rockstroh, Babette. "Ultrasound Travels The Politics of a Medical Technology in Ghana and Tanzania." Universitaire Pers Maastricht, 2007, 71.
[35] Müller-Rockstroh, Babette. "Ultrasound Travels The Politics of a Medical Technology in Ghana and Tanzania," 77.
[36] World Health Organization,"Interagency List of Priority Medical Devices for Essential Interventions for Reproductive, Maternal, Newborn and Child Health," 2016.

Observations and conversations within the Labor and Delivery and Maternity wards, indicate that the presence of fetal ultrasound technology moved beyond its intended diagnostic purpose. The process of ultrasound's institutionalization into the local world of CCTH mediated relationships between health professionals, students, and patients. Ultrasound influenced the way patients viewed their pregnancies and how doctors treated their patients. Even the presence of a broken, unusable ultrasound affected the clinical setting. Ultrasound's transfer to CCTH acted to add to the device's meaning and purpose both within the clinical and public health context.

Ultrasound Mediates Interactions Between Clinicians and Patients

Hierarchical dynamics between doctor and patient

When women became patients for ultrasound, it seemed to make the power disparities of the doctor-patient relationship even more apparent. During rounds, medical students presented each mother's case and then the doctor would ask the patient questions about their food intake, pain levels, and any other concerns. Compared to doctor-patient interactions in Oregon, the Ghanaian doctors often ran through these questions with basic, even impatient responses. But when women entered the imaging room or an ultrasound was wheeled to their bedside, the presence of the machine became a barrier that further highlighted the separation between unknowing patient and highly skilled physician. The doctor claimed his space behind the ultrasound machine, his eyes fixated on the monitor, which was only visible to him. There were only brief words exchanged between doctor and patient and once the exam began, the only thing connecting the two people was the transducer probe the doctor moved across the

women's abdomen. The monitor, fixed in place on this ultrasound model, was never made visible to the women lying on the examination table. Printed images were only shown and explained to the women to convince her to seek treatment or change a behavior.

In Oregon, the dynamics between ultrasound operator and patient are different because the context within which the ultrasound operates is different. In Oregon, ultrasound is an expected part of prenatal care with an additional psychosocial element. Expectant parents in the US see ultrasound as an opportunity to see and bond with their baby before it is born. Also, ultrasound machines in the US are operated by ultrasound technicians, not medical doctors as is done at CCTH. These combined contextual factors mean there is less of a divided knowledge and power base between ultrasound operator and pregnant patient in the US. There is more communication regarding the ultrasound as the technician translates the ultrasound from medical to lay terms.

Ultrasound Affects Perceptions of Illness and Treatment

Making women into ultrasound patients

At CCTH, the presence of ultrasound pushed for health professionals to fit pregnant women into patients for the technology. In Cape Coast, the majority of women were not present in the imaging room for a regularly scheduled ultrasound. Only once did I see a women demand an ultrasound to prove she was pregnant (however this observation could be explained by my limited time in the ward). Pregnant women are moved through the clinical space of the maternity ward or emergency block before they

become ultrasound patients. Usually, in the later stages of pregnancy, gestational age is determined using the date of the patient's last menstrual period and palpation of the uterus. Doctors obtain fundal height by palpating the women's abdomen, using what one medical student called "hand knowledge" to feel where the upper edge of the uterus, called the fundus, sits in relation to bodily landmarks like the pelvic bone. However, when the fetus is turned transversely or the muscles of the abdomen contract, establishing fundal height by hand became impossible. When these physical barriers are paired with perceived ignorant patient knowledge or lying regarding their last menstrual period, women are sent for an ultrasound to determine gestational age. Women are also passed on to ultrasound when palpation or other physical symptoms point to possible abnormalities or to determine if a cesarean section is needed during labor. Once women became ultrasound patients, the technology has continued effects as restricted availability and operation by doctors influence the dynamics between clinicians and their patients.

Altered patient treatment protocol

The restricted availability of clinicians to perform ultrasound influenced clinical protocol. After 4:00 pm, through the night, and on Sundays, ultrasound operators were on call but not necessarily present on hospital grounds. When a nurse or medical student thought one of their patient's needed an ultrasound, they had to consider the mobilization of resources required. The medical student or nurse had to contact their superior, a charge nurse or even a resident doctor at home, who would then call the on call ultrasound operator. To request using the ultrasound required a balance between knowing enough about their patient's condition to convince their superiors and needing

more information to warrant the resource. Sometimes, the presence of ultrasound technology in these situations when the operator was not on the ward floor prevented pregnant women from receiving the diagnoses and treatment they required. On the night I stayed in the maternity ward for a night shift, a pregnant woman was admitted through the emergency block in the early hours of the morning with what the young intern thought was obstructed labor. In discussion with a few nurses, he mentioned wanting an ultrasound immediately. But the senior nurses asked if he was sure, did he really want to call in for an ultrasound or could it wait until the morning. With these comments, the intern deemed the patient's case was not an emergency despite the fact that had this patient arrived during the day, when a resident doctor was present, she would have most likely been sent for an emergency ultrasound. Instead, the woman was transferred to the maternity ward to continue laboring and wait until a doctor arrived in the morning to perform an ultrasound. The doctor arrived on time for his shift and performed the ultrasound. The prolonged obstructed labor caused the women to suffer from an obstetric fistula, but the baby was born healthy. This example shows that when operational resources are limited, ultrasound has the power to alter what is considered an emergency and change the way clinicians refer their patients for ultrasound imaging.

Context Attributes Ultrasound with New Meaning and Purpose

A video for women

In Ghana, ultrasound comes into contact with patients who do not have the same perspectives of biomedical science that western patients do. At CCTH, having an

ultrasound examination became “doing a video” or “getting a video”. In the global north, it is a common assumption that ultrasound provides pregnant women with knowledge about viability, development, sex and position of their baby. However, observing women get ultrasound scans in Cape Coast disrupted the idea that this knowledge, and what women get out of ultrasound, is universal. Local bodies of knowledge changed the way ultrasound was understood by pregnant women. In Cape Coast, ultrasound became less of a way for women to emotionally connect and bond with their babies and more of a mode to further medical care, to move them through the hospital. Rarely was the ultrasound image explained to the women during the examination, unless it was being used as a way to change her behavior or get her to comply with treatment. Clinicians would refer to the ultrasound, telling the patient to eat healthier, stay off their feet, drink more water, or take their medications because the baby was too small or amniotic fluid too low. And rarely did women request an ultrasound or schedule one themselves; instead, receiving an ultrasound was something done at the request of nurses or doctors with no questions asked.

Ultrasound was experienced as something used in traumatic moments or to confirm the worst. Some women called the transducer a torch that could see everything. Other women said the ultrasound examination was actually treatment that stopped bleeding or changed the position of the baby. These perspectives can be partially explained by the lack of communication between doctor and patient during the ultrasound exam. Women had to ask to see the baby, for the monitor, and the whole machine in some cases, to be turned so they could see. But with the strict gap in expertise and authority that divided doctor and patient, this request was rarely voiced.

The doctor would often explain fetal anatomy on the screen to medical students, his nurses, and me as we stood behind him. But all while the monitor faced him, the wires and paneling of the back or side of the monitor facing the patient. With less explanation and different clinical uses, ultrasound loses its element of psychosocial entertainment it held in the global north and becomes a strictly clinical tool associated with patient fear and emergency.

Limited technology as a push factor for clinicians

As previously discussed, ultrasound technology is still concentrated within private sectors due to colonial history and modes of international technology transfer. As Müller-Rockstroh explains, "the general shortage [of ultrasound machines] aggravated the disproportionate distribution of staff in urban and rural areas of the country, a remnant from colonialism that had never been fully overcome despite attempts by the postcolonial government."[37] In a general sense, this pattern contributes to emigration of maternal and newborn healthcare professionals to private healthcare facilities or to other countries to work with the technology that best serves their profession. The resulting unequal distribution of health professionals is in the reverse distribution of patients these doctors and nurses are to care for. The lack of properly functioning or adequate ultrasound equipment paired with the knowledge that it was within reach elsewhere seemed to contribute to job dissatisfaction and low morale among doctors and nurses. Other factors such as better wages and work environment also contribute to this movement of health professionals away from public health

[37] Müller-Rockstroh, Babette. "Ultrasound Travels The Politics of a Medical Technology in Ghana and Tanzania," 80.

facilities, and in this context, ultrasound becomes a technological factor that aggravates this pattern.

At CCTH, many of the medical students expressed desires to leave Cape Coast after graduation to work in larger facilities in Accra or at privately owned hospitals. These comments often arose in frustration after, for example, an ultrasound machine only printed images with black and white stripes or when the line in the corridor outside the imaging room was so long someone's patient simply left the hospital rather than wait. One medical student said he has read about fetal ultrasound in many textbooks at university, but as a third year student had not yet used one in the clinical setting. Another more senior student agreed with this comment explaining that when he was finally tasked to use one to determine if a women needed a cesarean section, found himself feeling unprepared and nervous despite his advanced experience at the hospital. These medical students sometimes turned to me with exasperated questions like "is this what happens in America?" When these questions and situations arose, I could not help but see in my head the Maternal Fetal Medicine clinic in Oregon with its hallway of private rooms, each equipped with its own advanced ultrasound machine. And the fact that even when I was a high school student, I had the ability to see ultrasound in action, to have its technology explained to me. But here in CCTH, the absence of the technology had an influence on students who read about ultrasound in textbooks, a situation that seemed to elevate ultrasound as a foreign technology. While the lack of ultrasound contributed as a push factor, the valued presence of the limited technology was also employed a pull factor for health professionals.

Functioning ultrasound technology as a magnet for clinicians

As an advanced technology, ultrasound was used to attract health professionals and students to CCTH. Ultrasound gained a new script as a magnet to keep and bring doctors and nurses to the country and the public health sector. Ultrasound technology was something used to attract even me, a foreign undergraduate student, to shadow in the particular wards with the machines. In this way, ultrasound become part of the hospital's national image, a way for Ghana's public health sector to keep up with the advanced medical technology used around the world and to make visible their country's ability to provide up to date medical care.

Ultrasound becomes a teacher

Combined with the absence of senior staff, ultrasound also became a teacher, a source of information for medical students. Unlike senior doctors and nurses who sent patients to ultrasound only for particular suspected abnormalities or emergencies, students wanted to send many more of their patients for ultrasound. However, these medical students called for ultrasound for a variety of other reasons such as to confirm gestational age or lie of the baby. Even when medical students seemed confident in the issues they detected, they still sent women for an ultrasound to "fine tune their hands" as one medical student put it. Ultrasound was able to provide them with feedback on their palpation, calculations, and diagnostic skills like a senior clinician would have if present. In this way, ultrasound then prepares medical students to work accurately when the technology is not available and verifies their clinical skills.

Ultrasound as a public health booster

In the imaging room at CCTH, an ultrasound sound machine sat unused next to a supply cabinet in the corner. When I asked a nursing student why no one was using that one despite the long line outside, she responded that it was donated, sent over by a volunteer doctor from Germany after he left, but had recently started malfunctioning. I asked if it could be fixed and the nursing student replied that it probably could but there was no one to fix it. With the spare parts unavailable and no set plan for maintenance, the machine remained broken.

In Ghana, ultrasound moves between being a device placed to improve maternal and newborn health statistics in extreme cases to a purchased device used to boost the national public healthcare system. Ultrasound takes on a different purpose when it shifts from being a donated gift to a commodity purchased by the state. Despite the fact that foreign donations are free, accepting donations of ultrasound technology often resulted in more costs later to repair broken or inconsistent machines due to a lack of spare parts, maintenance instructions, or the local infrastructure to do so. But often when the Ministry of Health purchases the ultrasound technology with its own resources with direction of local hospital boards, ultrasound becomes something that offers elevated authority and coordination within the local healthcare system and attracts health professionals to stay in public facilities. Ultrasound becomes an item of prestige as its value is partially from people knowing of the technology's presence not just how it is being clinically utilized.

Purchasing ultrasound technology as a commodity can give the local healthcare system and hospital administration a type of power, prestige, and authority that is lost

when ultrasound is donated. Depending on the nature of the donation, the authority of where to put the ultrasound, who is trained to operate it, and what level of the technology can remain with foreign donors. However, purchasing the ultrasound technology can allow the local systems to make demands. When ultrasound is purchased by the MOH, preparation and coordination is required to make the best use of monetary investments. Ultrasound received as a gift "does not make any demands with regard to prior knowledge, information or experience but it may also obstruct the spreading ultrasound knowledge beyond individual hospitals."[38] Donations are often scattered throughout the country without the opportunity or time to create a foundation to support the technology, such as training and maintenance routes. But when the technology is purchase by the state, there is more opportunity for preparation and coordination so that the expensive machine can operate more sustainably within the local context. This often means maintenance plans are coordinated and funds are set aside to maintain the technology. This preparation also distributes knowledge and training to a wider range of clinicians and hospitals. When the state plans to purchase an ultrasound, they have the ability to train operators and find where it is most needed, where it can operate most successfully.

Purchasing the ultrasound technology also meant the acquisition of more advanced technology that aimed to keep doctors and nurses more satisfied with their ability to provide patient care. This boosted health professionals' morale and ultimately patient care while keeping trained clinicians where they were desperately needed. In

[38] Müller-Rockstroh, Babette. "Ultrasound Travels The Politics of a Medical Technology in Ghana and Tanzania," 105.

this way, the prestige the hospital gained from placement of ultrasound technology translated to individual doctors' prestige. At CCTH, in the maternity ward, a new ultrasound machine had been purchased as part of a MOH campaign for maternal health. Many of the medical students were excited to see the clear fetal images it was rumored to produce and tried to switch resident assignments with others to see it. Overall, ultrasound technology as a gift and a commodity do not differ much in regards to the clinical purposes with which they serve their patients. However, they differ in their capacity to empower or exclude the local health officials and recognize the autonomy of Ghanaian ministries.

It is important to keep in mind that this planning and preparation does not always occur when the MOH purchases equipment. Thus, it is important to keep in mind that this distinction between gift and purchased commodity is not always so clear in reality. Often, the Ministry of Health purchases and installs equipment without the careful consideration required for the device to function properly. Or the funds the MOH uses to purchase equipment comes from international donors and is already earmarked for certain equipment.

Ultrasound as Broken and Limited Technology

However, these productive effects only hold true when the technology is reliably functioning, which is not always the case at CCTH. And when this advanced technology that is expected to boost morale and patient care malfunctions, the technology caused the opposite effects. A broken ultrasound machine held just as much power to shape with the clinical space as a fully functioning device.

The ultrasound machine that occasionally reported only flickering static stripes on the monitor affected the attitudes of health professional and patients, how people moved through the ward, and how their time was spent while in the hospital interacting with the device. According to the charge nurse in the maternity ward, the hospital had sent out for someone to come fix the malfunctioning ultrasound, but that had been weeks ago and no progress had been made. One morning, when the machine malfunctioned, the doctor simply stood up and left the room in frustration, leaving the women lying there with the ultrasound gel on her abdomen and a long list of other women waiting outside to be seen by the doctor. Patient frustration matched that of the healthcare staff and often led to patients simply leaving the hospital without being seen by a doctor or getting the imaging they required. When staff knew the ultrasound machine was acting out, they reconsidered who needed an ultrasound, only sending the emergency cases or patients that could pay immediately to imaging. Patients were also aware of the limited functionality and availability of the ultrasound machines, which caused feelings of desperation and anxiety among women in the maternity ward.

A few of the medical students tried to fix the monitor, tinkering with the panels and wires in the back in an attempt to clear the image of its stripes. However, these students were reprimanded by their resident who felt they were wasting time when they should have been preparing for rounds. The hospital had contacted the company that manufactured the ultrasound machine requesting repairs weeks before and no progress had been made. The medical students took it upon themselves to tinker with the machine when they had time, but were not able to repair it in the time I was in Cape Coast.

In countries where women have access to ultrasound as a routine element of prenatal care, ultrasound is a way to reassure women that there are no problems while transforming the fetus into the image of a baby with which they can connect. American ultrasound technicians maintain dialogue in a way that blurs distinctions between the technology's clinical diagnostic capabilities and psychosocial entertainment. But in regions like Cape Coast, where ultrasound has been transferred and inserted into a foreign local context, the technology takes on new meaning while also transforming the clinical world around it. Ultrasound was transferred to Cape Coast with the hopes of improving maternal health statistics, which have actually worsened in the last ten years, as regional maternal mortality rates are higher than they were in 2012.[39] The Ghana Health Service attributes this increase in maternal mortality to a decline in antenatal coverage, lack of skilled birth attendants, and increased teenage pregnancy rates. In context, ultrasound altered relationships between doctors and their patients, changed how pregnancy and related pathologies were viewed, and functioned as a "broken" technology. Ultrasound became a magnet for health professionals, a source of authority for hospitals and clinicians, and a stand in teacher for medical students. By allowing a view of the fetus, ultrasound influenced hospital protocol, heightened the expertise and authority doctors held over patients, and influenced the way women viewed their pregnancies. When the ultrasound devices failed to operate, the technology caused frustration and worsened patient care, but also allowed for local ingenuity in its repair.

[39] Dr. Nsiah,Asare, Anthony. "The Health Sector in Ghana: Facts and Figures 2017," 2017, 52.

These examples support the idea that local context matters for how a medical technology will come to function in the clinical setting.

Pediatrics Ward, Cape Coast Teaching Hospital

The nurse walks between mismatched cribs under a ceiling fan that pushes the 90 degree air around. Faded Disney character decals plaster the walls of the pediatrics ward. Winnie-the-Pooh in pale yellow watches over children with necrotizing fasciitis, casted limbs, and burns. Dora the Explorer waves to children with yellow fever, typhoid, malaria, and pneumonia. In the one-roomed NICU, the top of Cinderella's head peels off the wall as if to keep watch over the tiny babies lined up below. In the closet sized Recently Resuscitated Unit, Buzz Light-year stands guard over three babies as the nurses moves between their plastic isolettes, his presence adding to the crowded feel of the room. A nurse blows up a nitrile glove like a balloon and pops the index finger into the open mouth of a screaming baby who begins to suck on the makeshift pacifier. A little boy in an open-backed hospital gown runs after a toy truck he sent careening down the hall. At every child's bedside is a mother. They kneel on the floor, arms draped into cribs, they lean against the wall trying to see their children past the heads of doctors, they sit at the foot of beds rubbing backs and humming softly.

Chapter 4: The Pulse Oximeter

Oregon, United States

The computer cart enters the room first, pushed by a nurse who is followed by three doctors. The intern presents the patient's case, reading from the computer how she came into the ER for a high fever and vomiting, but turns out her heart had been failing for a while and she is in desperate need of a new one. The intern finishes speaking and the room is silent except for the continuous echo of beeping from the toddler's pulse oximeter. The device is clipped to her finger, the only one without chipped purple nail polish. The beeping is irregular; it matches the constant echo of the beeping in the neighboring room before speeding up for a few seconds then slowing down. The intern glances up at the monitor displaying pulse rate and oxygen saturation as if to avoid eye contact with the patient's mother. The nurse repositions the oxygen cannula across the girl's face. After a few questions are whispered across the sleeping patient, the group exits the room. The nurse returns to her seat behind a wall of computer monitors. The screens display the vital signs from every patient in the unit; the tones of pulse rates and saturation warnings beep like an unorganized marching band.

Cape Coast, Ghana

A women stands just outside the Recently Resuscitated Unit (RRU) looking in at her baby, her hand pressed against the window. Five days ago, her daughter was born with hydrocephalus; the baby's head has swelled to three times the size of her twig thin body. Her heart stopped and was restarted this morning and she was moved from the

NICU to the RRU. She is completely paralyzed but still cries, a strange strangled sound, big eyes open wide and unblinking. She is wrapped in a rainbow of hand-knit blankets, a portable pulse oximeter clipped to her impossibly tiny foot. The battery powered pulse oximeter is the only one on the ward floor. A nurse watches the small glowing screen on the device as she explains to the baby's mother, that she will put the baby back on oxygen if her blood oxygen saturation drops below 85 percent. The mother squints to watch the number on the device. A nursing student appears at the doorway anxiously asking for the pulse oximeter for another patient down the hall. The nurse glances down at the pulse oximeter on the foot of the baby one last time before pulling it off. She hands it to the other nurse as the device starts to blink low battery red.

Technology Overview

Pulse Oximetry is a non-invasive technique used to monitor oxygen levels in the blood. The pulse oximeter can detect low oxygen saturation in the blood, called hypoxemia. Hypoxemia is a risk factor that correlates with a variety of childhood and newborn causes of morbidity and mortality and is hard to detect until visible cyanosis, the blue coloring of tissues, is observed. Hypoxemia is one of the major complications of acute lower respiratory infection, the leading cause of death in children under 5 years of age in Ghana and many other countries around the world. Hypoxemia is also correlated with heart disease and heart defects, perinatal asphyxia, sepsis, pneumonia, and apnea. High blood oxygen saturation, called hyperoxemia, is also correlated with morbidities in children and infants such as brain injury and blindness. Therefore,

monitoring oxygen saturation levels so they do not drop too low or climb too high is a critical element of patient care.[40]

In the global north, a pulse oximeter is clipped to the finger or toe of a patient to continually monitor the pulse rate and blood oxygen saturation. In the hospital setting, this pulse oximeter is often connected to a monitor at the patient's bedside and is part of continuous monitoring of other vital signs.[41] Each pulse oximeter device consists of a computerized unit, probe, and a sensor that is in contact with the skin. Pulse oximetry "uses the different light absorption spectra between oxygenated and de-oxygenated hemoglobin to determine arterial blood oxygen levels."[42] Hemoglobin is the protein in blood that holds onto oxygen so it can be released to organs and other tissues. The device uses the absorbance of red and infrared light after it passes through the body tissues and blood to determine the amount of hemoglobin saturated with oxygen. Comparison of light absorbance at different wavelengths allows the technology to estimate the concentrations of oxygenated and de-oxygenated hemoglobin. Oxygenated hemoglobin absorbs more infrared light while de-oxygenated hemoglobin absorbs more red light from the device. The ratio between absorbed red verses infrared light is used to determine the level of blood oxygenation, a ratio that appears as a percent on the device's screen.[43]

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[40] Duke, T., R. Subhi, D. Peel, and B. Frey. "Pulse Oximetry: Technology to Reduce Child Mortality in Developing Countries." *Annals of Tropical Paediatrics* 29, no. 3 (September 18, 2009): 167.
[41] Durand, M, and R Ramanathan. "Pulse Oximetry for Continuous Oxygen Monitoring in Sick Newborn Infants." *The Journal of Pediatrics* 109, no. 6 (December 1, 1986): 1053.
[42] Nitzan, Meir, Ayal Romem, and Robert Koppel. "Pulse Oximetry: Fundamentals and Technology Update." *Medical Devices (Auckland, N.Z.)* 7 (2014): 231.
[43] Nitzan et al., "Pulse Oximetry: Fundamentals and Technology Update," 1058.

Since it was introduced in the 1980s, the pulse oximeter has become a widely used monitoring technology in clinical and surgical settings. In the global north, pulse oximetry is a basic standard of care used to continually monitor pulse rate and oxygen levels. The pulse oximeter is the device responsible for the audible beeps that echo throughout hospitals. In high-income countries, the pulse oximeter is an expected piece of medical equipment in ambulances, emergency departments, recovery rooms, and operating rooms. It is one of the first things health professionals clip onto their patients and it remains attached to patients until they are discharged.[44]

As a relatively basic, portable device with the power to improve healthcare across a broad level of clinical departments, many global health campaigns have pushed for the transfer of pulse oximeters to nations of the global south.[45] To address the issue of high surgical deaths in developing countries, the WHO launched the Safe Surgery Saves Lives campaign in 2007. This campaign included a published "Surgical Safety Checklist" that required a pulse oximeter to be present in every operating room.[46] And a few years later the Global Pulse Oximetry project was launched to further "promote the use of pulse oximeters in every operating room in the world."[47] Multiple studies have shown that the WHO's campaign has meant that most of the focus on pulse oximeters in low resource regions involves their placement in operating rooms. This focus overlooks the range of uses the device can serve in other clinical settings and the many barriers

[44] Chang, Meayoung. "Optimal Oxygen Saturation in Premature Infants." *Korean Journal of Pediatrics* 54, no. 9 (September 2011): 362.
[45] Duke, et al., "Pulse Oximetry: Technology to Reduce Child Mortality in Developing Countries," 170.
[46] World Health Organization. "WHO Surgical Safety Checklist." *WHO*, 2009. https://www.who.int/patientsafety/safesurgery/checklist/en/.
[47] World Health Organization, *Pulse Oximetry Training Manual*, 2011.

involved in implementation.[48] [49] These pulse oximeters "designed for use in resource poor settings are rugged and reliable."[50] However, this can often mean the devices are less accurate, more sensitive to movement, and require battery replacements.[51]

At CCTH, there was only one functioning pulse oximeter for approximately 40 patients in the pediatrics ward. In this section, I will explore how this affected the purpose and meaning of the pulse oximeter device namely: it's new clinical and social purpose within the ward; how it mediated interactions between health professionals and patient caregivers; influenced the way health professionals, students, and patients viewed illnesses and treatments; how the "brokenness" and limited nature of the pulse oximeter reorganized how patients and clinicians moved through the ward.

Pulse Oximetry Mediates Clinical Interactions

A bridge between professional medicine and local understanding

In addition to reporting numbers with clinical significance, the pulse oximeter mediated how doctors and nurses interacted with their patients and patients' caregivers. The head nurse in the RRU explained that she would often go get the oximeter just to show caregivers how the low number on the screen when it was clipped to their child meant something had to change to raise it higher. By pointing out the number and

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[48] Herbert, Lara J., and Iain H. Wilson. "Pulse Oximetry in Low-Resource Settings." *Breathe* 9, no. 2 (December 1, 2012): 93. doi:10.1183/20734735.038612.
[49] Verwey, S, and P D Gopalan. "An Investigation of Barriers to the Use of the World Health Organization Surgical Safety Checklist in Theatres." *South African Medical Journal* 108, no. 4 (March 28, 2018): 336.
[50] "First WHO Global Forum on Medical Devices: Context, Outcomes and Future Actions." *World Health Organization*, 2011. http://apps.who.int/medicinedocs/documents/s23217en/s23217en.pdf.
[51] King, et al. "Opportunities and Barriers in Paediatric Pulse Oximetry for Pneumonia in Low-Resource Clinical Settings: A Qualitative Evaluation from Malawi and Bangladesh." *BMJ Open* 8, no. 1 (2018): 9.

explaining its general meaning, nurses were able to outline the often complicated nature of hypoxemia and its treatment. The pulse oximeter was used as a tool to reveal to caregivers clinical information while commanding respect for the clinician's actions. In this way, the oximeter became a device that could bridge the gap between professionalized medicine and common understandings of wellbeing. It was a non-invasive technique that aided medical professionals in explaining to parents or caregivers that their child needed supplemental oxygen, medication, or a surgical procedure. This open form of communication seemed to decrease the knowledge and authority disparity between health professionals and patient family members as it sparked open communication and a desire to reach a common level of understanding. With the pulse oximeter's numbers as a mediator, doctors and nurses seemed more willing to take the time to explain treatment decisions and the patient's condition.

The Pulse Oximeter Affects Perceptions of Illness and Treatment

Parent caregiver perceptions

The pulse oximeter worked to change caregiver understandings of disease and perceptions of care. One medical student explained that without the pulse oximeter it is harder to get parents to accept oxygen treatment for their child due to the association of the treatment with death. Many children are put on oxygen when they are very ill and later die, causing a community association between the oxygen cannula and death. But the numbers on the oximeter act as a direct feedback tool, as proof the child needs oxygen. Showing parents the exact figure glowing on the pulse oximeter and explaining what the number signified helped clinicians explain the role of oxygen in sustaining

their child's life. Most family members readily accepted the explanation of the low number on the pulse oximeter and seemed to appreciate the health professionals that took the time to explain the situation. Additionally, with the pulse oximeter, children are put on oxygen earlier. This pattern is something the medical student mentioned he hoped would reverse the way oxygen treatment is viewed as parents saw the oximeter's numbers improving during oxygen treatment.

Confidence for clinicians

The availability of the oximeter to assess their patients also gave clinicians more confidence in their referral and treatment decisions. In young infants especially, low blood oxygen saturation is hard to detect and monitor with just a physical examination. Having the pulse oximeter provided reassurance for medical students and nurses, medical professionals within the clinical setting who were often treated as inferior by senior doctors. A third year nursing student in the RRU explained that having a visible number that reports "how the blood is" would determine what treatment steps she would take next or how the current treatment was working without having to consult a senior clinician. When the blood oxygen saturation level dropped below 85%, the baby was immediately put on oxygen until the number rose back up. If the oxygen saturation level was maintained at a healthy level, the nursing student knew the baby's position was suitable. With the pulse oximeter to show them how their treatments were working, the medical students and nurses had more confidence in presenting their patient to doctors during rounds because they had a concrete grasp of their patients' vitals.

Pulse Oximeter Gained New Meaning and Purpose

From a continual monitor to a spot-check device

Due to the limited presence of pulse oximetry devices in the pediatric ward, it became a spot-check device rather than a continual monitor. In just 30 minutes, the device moved from the finger of a little boy with pneumonia to the toe of a premature infant to the finger of a teenager with heart disease. The device is clipped on the patient's extremity and the patient is urged to remain still as a number appears on the screen with audible beeps of pulse rate. The numbers are recorded in the patient's chart after a few minutes and the clip is removed and placed on the next patient. In most tertiary care centers of the global north, an oximeter device is clipped to every patient in surgical, emergency, recovery, and intensive care units. In the US, the device takes measurements over time and alerts clinicians when numbers move out of normal range. At CCTH in the pediatrics ward, there was only one working device while I was there. This meant there was one pulse oximeter for nearly 30 children and 10 babies. To allow for the technology to serve each infant or child that might need it, the device was used for only a few minutes on each patient. Instead of taking measurements over long periods of time, the oximeter was used to take snapshot measurements.

A means to ration limited supplemental oxygen supply

At CCTH, there is a limited amount of concentrated oxygen available for supplemental oxygen treatment. This means oxygen treatment was reserved for patients who were in critical need. Due to these circumstances, the pulse oximeter became a way to ration oxygen to patients who had extreme hypoxemia and could stably use the

supplemental oxygen and therefore determined what constituted as critical need. When oxygen was not available or the numbers on the device did not deem the patient critical enough for supplemental oxygen, the pulse oximeter also allowed for the timely and effective use of other treatments. These maneuvers to increase oxygen saturation included assisted ventilation with room air, suctioning the airway, or repositioning the patient. In the RRU, the nurse showed me how she clipped the oximeter on the foot of the baby with hydrocephalus and asked me to watch the device. If the oxygen saturation number dropped below 85 percent in the few minutes we monitored it, she explained, the baby would be placed back on supplemental oxygen. If the number was in the low 90's we would just reposition the baby's neck and suction out her airway to clear it.

Pulse Oximetry as a Broken and Limited Tool

Mistrust of technology

In addition to the single functioning pulse oximeter, there was a collection of unusable devices in the pediatric ward. Most of these broken devices were portable and battery powered, the type of modified technology considered best suited to low resource settings.[52] These devices were unusable and sitting at the bottom of the storage closet due to lack of local replacement batteries that fit the machine and broken sensor probes. It is interesting to consider why these devices were never thrown away, but stored despite their uselessness in the clinical space. A third year nursing student explained that one of the pulse ox devices gathering dust in the closet kept presenting readings so

[52] Herbert, Lara J., and Iain H. Wilson, "Pulse Oximetry in Low-Resource Settings," *Breathe* 9, no. 2 (December 1, 2012): 90.

inaccurate that if they were true the patient would be dead. Before it simply stopped turning on, another pulse oximeter device was discovered to be off (when readings were compared to arterial blood gas) by a constant margin. So every time this malfunctioning device was used, health professionals had to mentally adjust the numbers on the screen before recording the blood saturation. The dependability of this method quickly became a concern and the device was shut away in the storage closet. For senior health professionals, these inaccurate readings and malfunctions of the devices led to a tone of mistrust regarding pulse oximetry. Less experienced nurses and students placed a high level of importance on the numbers the pulse oximeter presented, but senior health staff took the numbers as just a small element of their overall assessment of the patient. In a way the unusable pulse oximeters packed away in the closet became a physical reminder of the unpredictability and fickleness of the device.

Movement through the ward floor

The brokenness of other pulse oximeter devices and therefore limited availability of the device influenced how patients and clinicians moved through the clinical space. Since there was only one charged oximeter on the ward floor, nurses often had to move between rooms searching for the device. Running around looking for the device was most often done by more novice clinicians like nursing and medical students who also tended to rely more on the device for vital signs. However, the pulse oximeter was most often used in the recently resuscitated unit (RRU) where the babies had to be very closely monitored. This meant a nurse would often appear at the doorway of the RRU asking for the device or a clinician would have to leave the RRU in search of the device to bring it back. The pulse oximeter also determined where patients were

placed in the ward. The patients that were being spot-checked using the device were placed near each other and close to the RRU. Once their oxygen saturation was determined to be stable enough, in addition to other physical vital signs, the children were moved farther from the RRU where they were monitored less closely.

At CCTH, the pulse oximeter is not a device expected to be clipped to every patient or found in every room integrated into the monitoring equipment. It is not a device used to continually monitor patients, calling for attention only when something goes wrong. In CCTH's pediatrics ward, the pulse oximeter is a portable, battery-powered device that, due to its singular presence, moves around the ward depending on where it is needed. When available, the pulse oximeter offered health staff information regarding their patients' blood oxygen saturation and heart rate, which allowed for better tailored treatment decisions. The device was more than just a technology used to monitor patient vitals because in this unique environment, it became a changeable object while also working as an object for change. Its audible beeping and flashing numbers moved patients and medical staff through the ward, rationed oxygen, instilled confidence in health professionals, and bridged the gap between professionalized medicine and caregivers' understandings of their children's wellbeing. This example reveals that a unique clinical context can change the way even the most small, straightforward medical devices are experienced by doctors, nurses, and their patients.

Chapter 5: The Neonatal Incubator

Oregon, United States

The incessant beeping of machines and constant rasp of ventilators seem to be amplified by the overhead fluorescent lights. Alarms orchestrate the movement of nurses and doctors between the rows of plastic incubators and radiant warmers that line the walls and aisles of the large room. The walls are painted a pale yellow as if in an attempt to soften the sterile feel of the unit. Every time a baby is born the tune of the happy birthday song wafts out of speakers in the ceiling. Amid the hustle and bustle of clinical staff, medical equipment, and parents, the babies' cries can barely be heard. One tiny baby sleeps under the plastic hood of his incubator, his body so obscured by a ventilator, tubes, dressings, and monitor pads that the only clearly visible pieces of him are his bare toes. A blue and green banner with his name and a bible verse stitched into the fabric is taped to the side of his incubator, a brown teddy bear and a small hotwheels car are nestled in the corner. His mother sits in a chair next to the machine, her face level with her son's, trying to catch his eye through the plastic barrier between them. At the back of the room, a nurse explains to new parents that their severely premature daughter will be kept safe and sound inside the incubator, which she describes as a technological womb. Across the room, a team of nurses and doctors cheer as parents carry their baby out across the threshold of the NICU. In another incubator, a baby wails under the bright blue glow of phototherapy lights. She struggles to push her cries past the pacifier in her mouth, tiny fists grasping at the feeding tube taped to her cheek.

In a few hours, her mother will arrive and it will take three nurses and a respiratory therapist to place the baby in her mother's arms.

Cape Coast, Ghana

The ceiling fan hangs from the ceiling at a slight angle, making a rhythmic ticking noise as it spins. At first, only one baby in the incubator cries, pulling at the feeding tube in his nose. His fussing wakes up the second baby next to him in the incubator and soon they are both crying, the noise emerging from the incubator as a muffled echo. Another incubator holds three babies, all sleeping soundly despite the chaos in the neighboring incubator. The three sleeping babies appear blurry at the edges due to the thick plastic barrier of their incubator. A nurse cradles a baby in a nest of blankets and places her on a mattress under a bank of lights that act as a makeshift radiant warmer. A group of doctors exits the neonatal unit and a nurse motions for the mothers waiting outside to come through. Some mothers chat quietly to each other and their babies, tickling toes through the access ports of incubators and updating mothers who missed visiting hours the day before. But there are pockets of silence in the little room, spaces of emptiness where a mother once stood watching her baby sleep.

Technology Overview

An incubator is an enclosed device that provides a protected and controlled environment for high-risk, premature babies to develop. Babies are considered premature when they are born at least three weeks before their projected due date. These

premature infants do not have fully developed organs, leaving them highly vulnerable to a variety of complications, including infection and hypothermia. Many studies have shown that infant survival rates significantly increase when the surrounding environment is ideal.[53] Incubators are implemented to mimic the environment of the womb to create this ideal environment to help premature infants develop in a sterile area with optimal levels of temperature, humidity and oxygen concentration.

One of the major causes of infant morbidity and mortality in premature infants is hypothermia. After birth, infants are no longer in the temperature stable maternal environment and quickly lose heat to their new surroundings. Newborns and especially premature infants experience rapid heat loss because they have a large surface area to body mass ratio, underdeveloped subcutaneous fat, and thin, permeable skin. Physiological effects of hypothermia include metabolic stress, infection, dehydration, slowed heart rate, respiratory distress, brain bleed, and death. According to the WHO, moderate hypothermia calls for immediate warming and is recognized at a body temperature of 89.6 to 96.6° F. When an infant reaches severe hypothermia, a body temperature less than 89.6° F, "outlook is grave, skilled care is urgently needed" (WHO, 47). Newborns lose heat mainly through evaporation of amniotic fluid, but this can also occur if the baby is placed on or near a cool surface or moving air. Within the first few minutes after birth, skin temperature of the baby typically falls by 4 degrees. This means a newborn loses body heat at the same rate a naked adult would at a freezing temperature of 32° F. A baby is placed in an incubator to prevent this rapid loss

[53] Day, Richard L., et al. "Body Temperature and the Survival of Premature Infants." Pediatrics 34.2 (1964): 171-81.

of body heat that can lead to a variety of other complications by providing optimal temperature and humidity levels.

The invention and implementation of the incubator into hospitals, first in Europe and then the United States, in the early 20th century transformed premature infants from "weaklings" to "fighters".[54] Caring for this new category of person and the technology needed to sustain infants who should still be developing in the womb demanded the development of a specialized field of medicine now known as neonatology. In the global north, this advanced specialized and technological care is now standard treatment for premature babies. In the NICU, the incubator acts as an enclave for the complex technology implemented to monitor and sustain the premature infant. The plastic capsule and web of wires of the incubator are a hallmark of neonatal intensive care units in the global north. Blood pressure monitors, ventilation equipment, catheters, nasogastric tubes, and IV lines pass through the incubator and groups of skilled nurses and doctors assemble around it. Like ultrasound, the incubator has been studied as a technology that holds meaning outside of the clinical space.

The incubator has been studied in countries of the global north as an integral part of NICU culture and early parent-child relationships. The incubator has been explored as a technological barrier that limits bonding between parent and infant. The clear walls of the incubator invite the outsider to look in, but prevent the parent from physically touching their child. Sometimes parents go weeks or months before holding

[54] Mittal, Hitu, Lini Mathew, and Ashish Gupta. "Design and Development of an Infant Incubator for Controlling Multiple Parameters," *International Journal of Emerging Trends in Electrical and Electronics*. Vol. 11, 2015, 42.

their baby for the first time. And when the small circular doors on the side of the incubator are opened, this only permits a parent's hand to enter. And when the baby is finally placed in the arms of his or her parent for the first time, a web of wires and tubes come with the baby. As advanced technological territory, the incubator can also lead parents to feel unqualified or out of place in their baby's highly technical life. In a study on technology in the NICU, Manen aptly summarizes this idea writing, "the experiential sensibility of maternity and paternity may become tenuous, fleeting, and elusive as true contact remains out of reach".[55] With their baby inside the incubator, the parent remains on the outside, separated from their child by both the physical barrier of the incubator as well as the perceptions of the advanced technology surrounding it.

As large, very expensive devices that require steady inputs of clean water and electricity, incubators are a rare element of newborn care in low resource settings. There is a severe lack of study surrounding how incubators function in clinical settings of the global south, as most publications simply highlight the health statistics that call for "appropriate technology" for developing countries. International reports most often do not name neonatal incubators, which cost between $15,000 and $50,000, as "appropriate technology for developing countries" as the technology is not considered "available, accessible, and affordable".[56] Ghana's high infant mortality rate has sparked numerous campaigns focused on improving neonatal care through actions. According to the WHO, around 14 percent of under-five deaths in Ghana occur due to the

[55] Van Manen, Michael, "Technics of Touch in the Neonatal Intensive Care," *Medical Humanities*, no. 38 (2012): 93.
[56] World Health Organization, *Medical Devices: Managing the Mismatch* (Geneva, World Health Organization, 2010), 23.

complications of preterm births. In Ghana, 14 percent (140,000) of babies were born prematurely and 8,400 of these babies died in their first 30 days of life. In Ghana, causes of preterm birth include infection, malaria, HIV, and the high adolescent pregnancy rate. In Cape Coast, preterm death has been stuck at a high plateau for nearly a decade. In a five-month period in 2017, 166 out of 406 births were premature babies and 50 of these babies died at CCTH, pushing CCTH well above the national average for premature infant deaths.[57]

Ideas for how to solve this problem depend on multiple actors. In a report introducing the Newborn Care Programme, the Ghana Health Service calls for improved care of the preterm infant, naming Kangaroo Care, which involves close skin-to-skin contact between mother and newborn "as an effective method of providing additional care to these vulnerable babies".[58] However, the Medical Director of CCTH blames "insufficient incubators and lack of space" as responsible for the high rate of preterm death and praises the donation of an incubator to the ward.[59] The Ghana Health Service suggests turning to alternative methods of preterm infant care, while the hospital board views attainment of new incubator technology as the path to improved care. Despite the drastic need to improve premature infant care, there is a disparity between approaches that affects the way incubator technology is utilized.

In the following section, I will explore how the infant incubator operates within the high-risk infant care context of CCTH. While I was shadowing at CCTH, the

[57] Dr. Nsiah,Asare, Anthony, "The Health Sector in Ghana: Facts and Figures 2017," 2017.
[58] "GHS: Newborn Care Programme," *Ghana Health Service*, 2017.
[59] "Cape Coast Teaching Hospital Gets Incubator." *Ghana News Agency*, 2017. https://www.gbcghana.com/1.11284602.

neonatal intensive care unit was a small room within the pediatrics ward. In this room, there were three enclosed infant incubators, 7 open isolettes, two unused incubators and a makeshift radiant warmer. This room served the over 700 infants requiring intensive care that came through the hospital in 2017. The incubator technology affected the clinicians, patients, and parents through its presence, absence, and brokenness in the pediatrics ward. The few incubators available affected the movement of healthcare staff as well as relationships between doctors and patients, and patients and their caregivers. The brokenness and limited availability of the machine altered when it was utilized for patients and led to the development of alternative techniques of care for preterm infants.

Incubator Mediates Clinical Interactions

Crowding connects mothers

Each incubator in the neonatal room holds three babies and most of the open isolettes hold two babies. There are three tiny babies sleeping in the middle incubator, one baby is on oxygen, one is so thin the flutter of her heartbeat can be seen across her chest, the other sleeps soundly, his arm laid across the baby in the middle. A small group of women are gathered just outside the room and when the doctor leaves, finished with his rounds, they seem to move as one through the swinging doors and into the room. They each walk up to the middle incubator, positioned so that each mother hovers above her own baby, their arms touch, body's leaning against each other.

Due to the limited number of incubators and large number of high-risk babies, no incubator was occupied by just one baby. For most of the time I shadowed in the

ward, there were three babies in each incubator. This meant there were three mothers, or grandmothers or aunts if the mother had died, in close physical and emotional proximity to each other. For days and even weeks, these mothers, grandmothers, and aunts visited their babies and went through the distressing experience of having a high-risk baby in the hospital together. Mothers with babies who had been in the high-risk room for weeks supported new mothers whose babies were recently transferred. Some women were afraid to touch their babies because they appeared so fragile, but the more experienced NICU caretakers encouraged them to bond. They ate meals and hung laundry together on the lawn outside the pediatrics ward. They updated each other if one woman could not make it to see her baby. These mothers and mother figures met at an incubator, but formed circles of emotional support that extended outside of the NICU and across generations. This community bonding seemed to act as a support system that helped them process the trauma and challenges of mothering babies inside an incubator. In this way, the incubator in the context of CCTH became an object that brought caretakers together, bonding them under the stress of trying to mother in this high risk, high tech environment.

Barriers between parent and baby

The incubator retained its capacity to physically and emotionally separate mother from baby in Ghana. After a healthy, full term baby was delivered at CCTH, it was most often placed on the bed next to the mother in the maternity ward. But if the baby required a controlled environment or close observation, he or she was transferred to the high risk room in the pediatrics ward down the hall and placed in an incubator if space was available. One mother argued against her baby being transferred into the

incubator exclaiming that if he went back, she would not get to see him until he was discharged. For mothers, visiting their babies meant first having the strength to stand and walk down the hallway to the pediatrics ward. Once there, they would often have to wait in line for a nurse to give them an update on their baby. After all of this, mothers were permitted to go back to the crowded high-risk room to see their babies. But once there, with her baby in view, the mother still encountered factors that prevented her from bonding with her child. First, there was the obvious plastic barrier of the incubator that prevented most physical touch. In addition, there was the less tangible barrier of unfamiliar and intimidating medicine and technology. This gap between medicalized baby and lay caretaker was amplified by the constant presence of healthcare staff, and the tubes and wires surrounding the baby. Many women stood just outside the room or up against the wall, as if these barriers created another physical gap between mother and baby. In some instances, doctors and nurses would chastise women for trying to hold their baby or getting in the way of medical staff. Even as the incubator technology moved across countries, institutions, and cultures from the global north to the global south, it maintained its powerful ability to act as a barrier between mother and child and to push mothers to doubt their role as caretakers.

Elevated professional medicine

When morning rounds begin, the nurses usher many of mothers standing at their babies' incubators out into the hall to make room for the doctors. A few mothers who are breastfeeding remain inside. The group of doctors moves from one end of the room to the other, reading patient charts and discussing treatment plans. A medical student

silently draws blood from two babies in the corner incubator and soft crying fills the room. The group of doctors make it to the end of the room where two mothers sit, feeding their babies. Each of the doctors greets the women, but once conversation regarding this baby's pneumonia and that baby's weight begins, the mothers are ignored.

Like the ultrasound machine, the infant incubator acted as a piece of equipment that further heightened the disparity of power and knowledge between medical professional and patient. As discussed above, mothers were often pushed out of the clinical space surrounding the infant incubators with both direct words and subtle feelings of unfamiliarity. There was little effort put in to explain the medical proceedings involving the incubator, which most likely contributed to the feelings of distance mothers felt from their babies. Very rarely did parents approach doctors to ask questions regarding their baby. Unlike in Oregon where medical staff made efforts to welcome parents, both Mom and Dad, into the intimidating high-tech environment, during rounds in Cape Coast, nurses and doctors often told mothers to "back away" or "come back another time." Mothers could only stay for a few hours at a time before they were ushered out and fathers were rarely in the NICU. However, the mothers never went far when they left the NICU, many stood just outside the room or grouped together in the grass just outside the pediatrics ward doors.

Incubator Affects Perceptions of Illness and Treatment

Qualifying babies for the incubator

In the middle of the night, a mother arrived in a taxi and was admitted to the maternity ward with obstructed, early labor. Her son was born severely premature via an emergency cesarean section; he was so small his whole body fit in one of the doctor's hands. Instead of being immediately transferred into an incubator due to his low birth weight and underdevelopment, the baby was left with his mother in the maternity ward until arrangements could be made for him in the neonatal ward. The next day, a baby had to be moved from an incubator to the make shift radiant warmer to make room for the new baby who was considered higher risk. The baby previously being cared for under the makeshift warmer was released onto the general pediatrics floor.

Due to its limited availability, the presence of incubator technology affected what qualified babies as high risk. To improve premature birth outcomes, the WHO recommends unstable babies weighing less than 2,000 grams or less should be placed in a "thermo neutral environment either under radiant warmers or in incubators." [60] But at CCTH, there were not enough incubators or warmers to hold every unstable baby that met these criteria. The incubators became a rationed resource where only the most unstable, high-risk infants were placed. This forced the doctors and nurses to assess each potentially high risk baby and determine if their condition was detrimental enough to warrant them a space in an incubator. As a result, many babies who should have had

[60] World Health Organization. "Thermal Protection of the Newborn: A Practical Guide." Geneva, 1997.

constant care in a thermo-controlled, sterile environment, were instead in open isolettes on the general pediatrics floor or in the maternity ward with their mothers.

Mothers' perceptions

The unexpected birth of a premature infant is traumatic and the use of the incubator technology affected the way mothers viewed their sick infants. Many mothers remarked on the fact that first seeing their babies inside the incubator made them seem even more fragile and vulnerable. One nursing student explained to me that many mothers associated the incubator with infant decline and death. Only the most high-risk babies are placed in incubators and some get even sicker or die there. However, many mothers also talked about the strength of their babies to fight and get healthier within the neonatal unit. With this perspective, the incubator became a facilitator of the baby's progression from fragile premature infant to courageous fighter. In this way, incubators at CCTH affected mothers' perceptions of their sick infants in two drastically different ways. The incubator both magnified the perceived vulnerability of the preterm infant, but also pushed some mothers to see their babies' strength while becoming a relied upon tool for the babies' survival.

Incubators Gain New Meaning and Purpose

Mediators of alterations to traditional practices

At CCTH, the incubators gained new meaning as part of public health campaigns to improve infant mortality rates. The Ghana Health Service's "Newborn Care Programme" to improve thermal care pushed to modify the way mothers, birth attendants, and health staff cared for premature infants. With the purchase of two new

incubators as part of this "Newborn Care Programme" came the push for other aspects of this campaign to be implemented as well. The Newborn Care Programme recommended delayed bathing, immediate wrapping and skin-to-skin contact.[61] For mothers and family members, this campaign pushed against some traditional birth and bathing practices.

Early bathing is a major contributor to hypothermia in newborns, and according to the Ghana Health Service should be delayed to help the newborn retain body heat.[62] However, in Ghana, bathing the baby immediately after birth is associated with helping the baby sleep and feel clean, shaping the baby's head, and decreasing body odor later in life. It is believed that the fluids on the baby's skin will enter their body and cause body odor later in adulthood. A charge nurse in the neonatal unit explained that for at-home births, babies are bathed immediately and immediate skin-to-skin contact is uncommon. Often the baby is left unwrapped as the birth attendant tends to delivering the placenta, because until the placenta is delivered, the consequences of leaving the newborn unattended are less serious than leaving the mother unattended.

Under this national campaign, clinicians were encouraged to improve close monitoring of infant body temperature, resuscitation training, and delay in hospital bathing. The campaign also called for clinicians to recommend the use of Kangaroo Mother Care, which involves early skin-to-skin contact between mother and newborn, as an approach to maintaining infant body temperature both at the hospital and for at home births. One nursing student was charged with explaining direct skin-to-skin

[61] Ghana Health Service, "Newborn Care Programme," 2015.
[62] Ghana Ministry of Health. "Ghana National Newborn Health Strategy and Action Plan," 2014.

contact to new mothers in the maternity ward. The nurse explained to me that skin to skin contact is not a common practice because mothers are exhausted and ill or due to beliefs that the baby was too fragile or needed to be cleaned first. She said skin-to-skin contact within the hospital is encouraged to a higher degree when the neonatal unit and its incubators are full. Despite it not being a common practice, most of the mothers in the maternity ward readily accepted Kangaroo Mother Care and expressed their happiness in getting to keep their baby closer to them as opposed to in the neonatal unit.

Many medical students explained that because the alternative bathing guidelines pushed to change traditional birth practices, they had not been very successful in reducing premature infant morbidity and mortality. Despite the push for preventative practices to reduce hypothermia and alternative treatment approaches, the neonatal unit and its incubators remained crowded. In this way, incubators gained meaning as part of the national campaign to improve high-risk infant care and treatment approaches at CCTH.

The Incubator as a Broken and Limited Technology

Creation of improvised incubators

Due to the price of purchase and resources required to maintain incubator technology, the incubator to baby ratio was high at CCTH. Incubators were a precious resource so when the equipment broke or malfunctioned, local resources were used to try to fix the incubator. When the top hood of one of the incubator's cracked, a new top was refitted to work. The new hood was from a long out of service incubator that has

been kept in storage. A local technician was able to resize the old incubator hood to fit securely onto the bottom shell of the functioning incubator. Just because some piece of medical equipment is broken did not mean it was useless. Old, broken equipment was kept on the ward floor because it still has use as a source of spare parts and meaning as source of technological pride. The inclination to fix the incubator also highlights the creativity and ingenuity of a population often stereotyped as needing outside help.

To maintain newborn babies' body temperature when the available incubators and space were at capacity, hospital staff put together a makeshift incubator. This provisional warmer consisted of a bank of fluorescent lights leaned against the wall next to a low-rise hospital bed. Babies would be wrapped in blankets and placed on the mattress under the lights. A medical student described this set up as "better than nothing" but explained that because it is not enclosed like an incubator, the baby is at a higher risk for infection and dehydration. There is nothing to prevent the baby from breathing in the germs and dust in the ambient air either. And without ability to control humidity, the baby's skin will lose more water to the environment. It is also impossible to maintain a consistent the temperature of with this radiant warming technique.

However, the radiant warmer provided the warm environment that most low birth weight, high-risk babies require to develop. Additionally, many mothers and nurses preferred the makeshift incubator to the enclosed, plastic incubators. Babies placed in the makeshift warmer were not closed off from the outside world by a physical barrier as they were in the enclosed incubators. This granted nurses easier access to the baby for clinical tasks that had to be performed routinely such as taking blood, monitoring blood pressure, and administering medication. And mothers with

babies in the makeshift warmer had more access to interact with and touch their babies compared to mothers with babies in the enclosed incubators. The typical incubator is designed to be an external plastic womb, a piece of technology that provides a warm, clean, safe place for the infant until it can survive in the outside world. But when this technology is absent, innovative ideas to keep the baby warm like this one came into play.

Storage and spare parts

There were two unused incubators pushed up against the wall in the high-risk baby room. One of these incubators held neatly folded piles of blankets and packages of sterile gloves, and the other was being used as a hard surface to write in the patients' charts. One of the incubators never even functioned within the walls of CCTH because they required an electricity voltage the hospital's power grid could not sustain. The other incubator had been functional, but its temperature sensor broke down a few months prior. The company that donated the machine no longer made spare parts for the outdated version. When I asked why the machines weren't just thrown out, the nurse replied that they were very expensive machines, that they planned to bring in a local repairman to try and get it working again. These incubators were broken, nonfunctioning pieces of medical technology, but they were not thrown away. Instead, they were repurposed in order to maintain their station in the clinical space. It is interesting to consider why the equipment was not simply thrown away or moved to storage. This propensity to keep non-functioning equipment on the ward floor speaks to the mindset that technology is a critical aspect of neonatal care. As an outsider, I initially saw the broken incubators as useless; they took up space in the cramped unit

and served no true purpose. But for the staff at CCTH, even the nonfunctioning incubators seemed to represent their ability to provide healthcare with highly technical medical equipment while also embodying a culture of technological tinkering and repurposing. The simple presence of the incubator technology, both broken and functioning, seemed like a way to show with pride that CCTH was capable of integrating advanced medical equipment into neonatal patient care. This ideology that infant care requires the presence of technology is rooted in Western biomedicine and is transferred to the global south along with foreign medical equipment and international public health campaigns.

The infant incubator maintained its function to mimic the safe, controlled environment of the womb, but also adopted new meaning within the neonatal unit of CCTH. The limited availability of incubators paired with the high number of premature patients mediated interactions between clinicians, babies, and caretakers. While the incubator acted as a barrier between mother and baby and highlighted the disparities of expertise and power between doctor and caretaker, it facilitated supportive bonds between mothers. The incubators altered the way both clinical staff and mothers perceived the condition of the premature infants. New meaning was attached to the incubator as part of a national public health campaign to improve newborn care that pushed against common birthing practices, but also introduced skin-to-skin contact to improve thermal care. Broken incubator technology also had the capacity to alter the clinical space as equipment was fixed, repurposed, and imitated. The inclination and ability to repurpose parts to fix a broken incubator and construct a makeshift warmer to imitate the incubator technology undercuts the idea that the answer to Africa's

healthcare barriers must come from the West. The above examples show that the staff and local engineers in Cape Coast have the capacity to physically adapt medical technology to allow it to function in its new context.

Chapter 6: Discussion

Context Matters

The lifesaving effects of medical technology in Ghana and around the world are undeniable. The invention, implementation, and spread of technology and techniques have played a role in improving health outcomes over the past two centuries in countries all over the globe. In the clinical setting, goals of medical technology include giving medical professionals increased information, accuracy, and efficiency in diagnosing and treating their patients. However, inserting this medical technology into a locality different from the one it was designed for altered the way the Ghanaian healthcare system operated as well as how the technology operated. The infiltration of health technology into the clinical environment of Ghana had a broad spectrum of influences on the communities with which it interacted. Within Cape Coast Teaching Hospital, pieces of equipment mediated how people interacted with each other, their illness, and their caretakers. The presence, absence, or brokenness of a machine altered hospital protocol and the ultimate meaning of the machine for health professionals, students, and patients. The design or availability of a technology worked to determine who operated the technology and how the patient or family member viewed their disease within their own lived experience.

The dynamic functionality of medical technology within unique contexts occurred in a variety of ways at CCTH. I discussed four main modes in which context mattered for the way each medical technology operated. First, each technology mediated clinical interactions between doctors, nurses, patients and caregivers. Second,

the presence of the devices affected both clinical and lay perceptions of illness and treatment. Third, all three technologies gained additional meaning and associations among clinical staff and patients. And lastly, each technology retained a capacity to influence the clinical space as a broken or limited piece of equipment.

In the section on fetal ultrasound technology, ultrasound's designation as a technology fit for all was challenged by discussion of the device's adapted dynamics within the context of CCTH. In the maternity ward, ultrasound technology mediated clinical interactions as it emphasized the doctor-patient knowledge and authority inequalities, increasing the social gap between professionalized medicine and lay patient. Ultrasound technology affected perceptions of illness and treatment by altering what was labeled as an emergency case and inciting health staff to fit pregnant women into patients for the technology. The ultrasound moved from being a routine prenatal tool to become an emergency video for women, a teacher for medical students, and a commodity for the public health system. Unreliable, malfunctioning ultrasound technology also had the capacity to interact with the clinical environment by affecting health professional's attitudes, how patients were moved through the ward and eliciting ingenuity in repair efforts.

In the pulse oximeter section, it was outlined that even the most basic device can change and be changed by the clinical context. In the United States, the pulse oximeter is a common tool used to measure blood oxygen saturation and continually monitor patients across a broad range of conditions. In Cape Coast, the device lost these characteristics and gained new functionality within the pediatrics ward. The pulse oximeter mediated clinical interactions by bridging the gap between professionalized

medicine and lay caregiver thus decreasing the doctor-patient power disparity. The pulse oximeter influenced perceptions of illness and treatment as a source of confidence for healthcare staff in their decisions and a means to change caregiver perceptions of oxygen treatment. Even as a basic device, the pulse oximeter gained new meaning to become a spot check device and a way to ration scarce oxygen resources. The limited availability of the pulse oximeter device was a factor in determining how patients and nurses moved through the ward, while its brokenness led to mistrust of the technology.

In the incubator section, the advanced technology was introduced as an integral aspect of NICU culture, an expensive device used to mimic the controlled environment of the womb for premature and high-risk babies in the United States. The incubator has the potential to improve infant care in the global south, but its high cost and need for consistent inputs of water and electricity often mean the device is not considered an "appropriate technology" for resource poor healthcare centers. In Cape Coast, the incubator maintained its capacity to obstruct bonding between mother and baby, but evolved in operation and experience within the clinical context. The incubators in the high risk baby room mediated interactions between people by connecting mothers going through similar emotional trauma, disconnecting mothers from their babies, and elevating the authority of medical professional over patient caregiver. The presence of the incubator technology affected both mother and clinical perceptions of illness and treatment. The incubator also gained new meaning as it was associated with a national public health campaign to improve newborn thermal care. As an advanced, expensive technology, the incubator also had dynamic influences as a broken and limited device. A broken incubator was used as a storage space, but also elicited ingenuity from local

staff and became a source of pride within the hospital.

Brokenness and Ingenuity

The functionality of broken technology is not only an inhibitory element, but a factor with the capacity to create constructive change within the healthcare system. The ideas surrounding broken medical equipment differ between Oregon and Cape Coast. In Oregon, malfunctioning or inaccurate technology was promptly removed from the clinical space. Oregonian healthcare staff did not take on the task of tinkering with the equipment. The technology either operated with its predetermined function or it did not, in which case it was replaced. In Cape Coast, the distinction between a working technology and useless machine was less clear. A broken piece of equipment was rarely immediately removed from the ward floor. Malfunctioning technology elicited improvisation and ingenuity from the local healthcare staff who took it upon themselves to tinker with the equipment in an attempt to repair it or grant it another purpose. Often times the malfunctions came as expected patterns in certain devices and clinicians already knew what adjustments were required. Equipment beyond repair with limited ties to maintenance institutions was repurposed or used for spare parts. When inoperable devices retained their presence in the ward, they became monuments of the hospital's ability to integrate highly technological elements into patient treatment.

Thinking about African healthcare staff as innovators and fixers allows for the reconsideration of the presentation of African healthcare as underdeveloped and in desperate need of Western assistance, a topic this paper alludes to but was unable to discuss in depth and one that warrants further research. Medical equipment received as donations from the global north was continually malfunctioning, or in extreme cases,

could never be powered on within the walls of CCTH. The many broken and faulty pieces of donated equipment also call for the reevaluation of medical technology donation. What is donated and how it is donated speaks volumes about the dynamics between sending and receiving institutions.

Clinical Distance

Comparison across the three medical devices reveals the power of medical technology to either generate or diminish distance between patients and health professionals. Ultrasound technology and the neonatal incubator created further distance between people by acting as communication barriers, reducing the need for physical patient contact, and increasing reliance on medical machine over trained person. In contrast, the pulse oximeter worked to pull patient and clinician closer together by mediating open communication, requiring consistent physical contact, and calling for human interpretation.

The ultrasound machine created space between patient and doctor by reducing the need for physical contact and verbal communication. Availability of the ultrasound diminished the need for palpation of a woman's abdomen. Information normally gained from palpation such as gestational age and position of the baby could be gained during an ultrasound exam instead. During the ultrasound exam, the only thing connecting doctor and patient seemed to be the transducer the doctor guided across the patient's abdomen. Conversation was rarely exchanged across the monitor's screen. Even though the doctor had opened up a window to peer into the insides of his patient, the distance between clinician and patient seemed amplified.

The neonatal incubator also functioned to generate space between health professionals, caregivers, and patients. The presence of the advanced technology seemed to push doctors to place sick babies inside the incubator rather than with their mothers. This reliance on technological care over human care not only separated baby from mother, but also distanced doctors from their patients and patients' caregivers. Inside the incubator, vital signs normally assessed by hand hourly by nurses were recorded by equipment integrated into the incubator. The plastic canopy and monitoring technology of the incubator also distanced the high-risk babies from the outside world. For a nurse to check the baby's blood oxygen saturation level or for a mother to change a diaper meant closing a large distance between technological womb and human touch.

In contrast to these space-generating technologies, the pulse oximeter functioned to minimize distance between health professional, patient, and caregiver. The use of the pulse oximeter functioned to decrease distance between health professional and caregiver by mediating open communication. Additionally, the pulse oximter's shift from a continual monitor to a spot check device at CCTH meant increased patient contact. In Oregon, the wide availability and accuracy of the technology meant nurses were only drawn into the patient's room when the monitoring screens in the hall alarmed for abnormal oxygen saturation. In this context, nurses could monitor patients from a distance, using and trusting the technology to determine when closer patient contact was required. In Cape Coast, the limited availability of the device meant nurses were in constant patient contact, moving the device from one patient to the next. And because the portable pulse oximeter was known to malfunction, nurses were also

carefully observing their patient's physical symptoms in combination with the pulse oximeter's numbers to ensure accurate assessment.

Limitations

Along with discussion of the results, this research has limitations that need to be addressed. One area of limitation is rooted in the method of qualitative data collection and use. I used my years of shadowing experience in Oregon to outline how medical technology operated in the global north, but I did not have field notes recorded from these experiences. Field notes from Oregon to directly compare to my Cape Coast field notes would have made my methods more reliable and open for analysis by other researchers. Additionally, while my field notes were taken in Cape Coast with an emphasis on medical technology, they were not recorded with a predetermined thesis topic as a guide. Instead the notes were used in combination with recollections to construct a research question and analysis.

My presence as a foreign student in Cape Coast also brings up potential limitations to this research. English is the official language in Ghana, but some patients spoke Fante or Twi. The information I gained through translation could have been biased or altered by the medical student or nurse translating for me. Knowledge of the local languages could have reduced this limitation and revealed more qualitative information about how technology affected the clinical space. My physical presence on the ward floor also affected clinical and patient interactions. As previously discussed, my presence as a foreign student was not a neutral factor and could have influenced the way I saw people and medical equipment interact. These limitations point to the need for further research on the topic of medical technology in different contexts.

Chapter 7: Conclusion and Nante yiye

All too often the transfer and integration of medical technologies in the global south are based on the simplistic assumption that the advantages of foreign technology are explicit and universal. Through discussion of medical technologies in the context of Cape Coast Teaching Hospital's paediatrics and maternity wards, I have aimed to show that these devices are both changeable objects and objects for change within the clinical setting. By exploring how the fetal ultrasound, pulse oximeter, and infant incubator gain and lose meaning and purpose, I have presented evidence against the idea that medical technology can be transferred globally and remain a static element of healthcare with direct paths to health equity.

Medical technology is undoubtedly a pivotal element of the healthcare system and patient wellbeing in Ghana, but as a culturally charged product, carries consequences beyond advertised medical purposes. In a place to which it had been exported, the medical equipment at CCTH was not just a one-way solution for improved health statistics as was originally intended. Not everything changes in the process of traveling medical technology, some aspects stay robust while others diminish, evolve, and transform. The dynamic experiences and use of medical technologies emerged by following the ultrasound, pulse oximeter and incubator into the working clinical context of Cape Coast Teaching Hospital. The three technologies of maternal and child health take on new meaning and purpose as they are integrated into the jobs, community, and illness narratives at CCTH.

These conclusions call into question the current use of medical technology as an exported object of global health aid and national development. This awareness that

context matters for the way medical technology is experienced and integrated contradicts the idea that foreign medical equipment donations to the global south is a fit for all answer to health and wellbeing. With these three examples of medical technology in context, talking about "appropriate technologies for developing countries" becomes policy talk rather than an observed reality. [63]

When medical technology travels from one nation to another, it encounters the cultural, social, political and economic institutions of a new context. With this understanding, medical technology cannot remain static as it travels, it cannot be expected to maintain the same meaning and purpose within a new context. In Cape Coast, medical technology became a warped mirror of personal wellbeing, an accessible teacher, a symbol of ingenuity, a source of pride, a token of miscommunication, and a bridge of understanding.

Medicine is not a neutral institution and the way it is exported can speak to the way we characterize people from other parts of the world. Exporting medical technology deemed appropriate for the global south often means differentiating these nations as the poor other, in need of support and products from the global north. With this tiered perspective of global health aid, it is difficult to foresee global health and development equality as a likely outcome. I hope that by exploring the way medicine travels, this thesis not only pushes for a deeper understanding of Ghana and its people, but a truer understanding of what biomedicine is and can become in the hands of all the world's people.

[63] WHO, "Medical Devices: Managing the Mismatch," 2010, 2.

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