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Stop Sepsis: Identification of Environmental Sanitation and Hygiene Interventions to Prevent Neonatal Sepsis in Two Hospitals in Amhara, Ethiopia

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By

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Bachelor of Science
Genomics and Molecular Genetics; Microbiology
Michigan State University
2019

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An abstract of a thesis submitted to the Faculty of the
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Abstract

Stop Sepsis: Identification of Environmental Sanitation and Hygiene Interventions to Prevent Neonatal Sepsis in Two Hospitals in Amhara, Ethiopia

By Kelly Geith

Neonatal sepsis is a serious issue with an estimated 3 million cases occurring annually across the globe. This burden is mainly in low- and middle-income countries and is partially attributable to unsanitary healthcare facilities and unhygienic caretaking practices. A previous study conducted in two hospitals in Amhara, Ethiopia found a 20% prevalence of neonatal sepsis among infants born at these two facilities and high levels of microbial contamination in the environment surrounding the newborns. The purpose of this project was to identify and develop evidence-based intervention recommendations for these two hospitals to reduce rates of neonatal sepsis and mortality. First, results of the previous study were presented to hospital staff and other stakeholders, including regional health authorities. Their written and verbal feedback and ideas for interventions were collected during a brainstorming session after the presentation. Then, a literature review was conducted to identify interventions which target areas of concern revealed by the previous study, and interventions which were successful in similar low-resource settings. Stakeholder feedback and evidence from the literature search were used to develop intervention recommendations for the two study hospitals. The interventions target six key areas: hand hygiene practice, hand hygiene infrastructure, hand hygiene for mothers and caregivers, waste management, environmental cleaning, and hospital management/leadership. These recommendations will be presented to hospital staff and other stakeholders and used to co-develop a quality improvement program to be implemented in these two hospitals.

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Chapter 1: Introduction

Ethiopia is a landlocked country in Eastern Africa [1]. Its 1.1 million square kilometers of land are divided into 9 regions and two independent cities [1,2]. There are over 108 million people in Ethiopia as of 2018 [1]. This number is rapidly growing as Ethiopia has the 22nd highest growth rate in the world of 2.5% per year. Most of the population live in rural areas with only approximately 20% of the population living in cities [3].

Ethiopia is classified as a low-income country with a developing economy [4]. Economic indicators show growth in the country, such as gross domestic product (GDP) tripling in the past 10 years [3]. Despite this economic growth, health expenditures as a percentage of GDP have decreased from 5.5% in 2010 to 3.5% in 2020. This data suggests that investments in health and healthcare are not growing as rapidly as other sectors of the economy. Despite this, substantial gains in the health of Ethiopians over the past decade have been documented. Over the past decade, seven years have been added to the life expectancy, which is now 67.9 years for females and 64.1 years for males [3]. The infant mortality rate has also improved from 59.8 deaths per 1000 live births in 2010 to 37 deaths per 1000 live births in 2020. These indicators show promise that changes in economic growth and the healthcare system can lead to improved health outcomes.

The healthcare system in Ethiopia has seen considerable growth and change starting in the 1990s. The Ethiopian Federal Ministry of Health established the Health Sector Development Program in 1997 to organize the healthcare system and promote healthcare accessibility, especially primary health services [5]. This program changed the structure of how healthcare facilities are managed to put more responsibility on regional and district-level offices of the Ministry of Health. The Health Extension Program was launched in 2003 by the Ethiopian Federal Ministry of Health to further expand primary care services to all Ethiopians [6]. Under this

program, thousands of primary care health centers have been built which offer free health services. As of 2017, there are approximately 200 hospitals and 3500 health centers in Ethiopia, the majority of which are owned by the Ministry of Health [7,8]. Hospitals are classified according to the size of the population that they serve. Primary hospitals serve the smallest number of people (60,000-100,000 people), general hospitals serve an intermediate 1-1.5 million people, and specialized hospitals are the largest, serving 3.5-5 million people [9]. Traditional healers are also very common in Ethiopia. It has been reported that up to 80% of Ethiopians seek care from traditional healers, particularly for primary care [10]. Patients seek care from traditional healers due to trust that they will receive effective treatments, low costs, and/or "a dissatisfaction with modern medicine" [11]. With a mixture of modern and traditional medicine available, a variety of healthcare options are available in Ethiopia.

Access to, and utilization of, maternal healthcare is highly variable for Ethiopian women. According to the 2016 Ethiopia Demographic and Health Survey, only 26% of women deliver their babies in healthcare facilities [12]. Geography plays an important role in this statistic with 20% of births in rural areas occurring in healthcare facilities compared to 79% of births in urban areas [12]. Education level of the pregnant women is also associated with the location of delivery. Women with a higher education (more than a secondary education) are more likely to give birth in a healthcare facility [12]. In addition to geographic barriers to maternal and postnatal care for women that live in rural areas, other factors contributing to women deciding not to give birth in a healthcare facility include limited planning for birth, lack of information about the advantages of facility births, cost, "abusive and disrespectful treatment, unskilled care, poor client provider interaction, noncontinuous care, lack of privacy, and traditional practices" [13-15]. The Federal

Ministry of Health has been encouraging maternal healthcare and births in health facilities through the Health Extension Program and the National Health Care Quality Strategy [6,16].

Women that give birth in a healthcare facility are recommended by the Ethiopian Federal Ministry of Health to stay in the hospital for at least 6 hours, and most women that have uncomplicated births are discharged from the facility within a day [17]. The babies are classified at birth according to their weight and gestational age which determines the standard treatment they will receive [17]. For newborns that have a normal weight ($\geq$ 2500 grams), mothers receive counseling on proper care for the babies and are discharged quickly. For babies with a low birth weight (1500-2500 grams) and/or born between 32-36 weeks, mother receive the same counseling as for normal babies, but the babies are transferred to the Kangaroo Mother Care units for extra monitoring. Babies born below 1500 grams or before 32 weeks of gestation may be transferred to neonatal intensive care units, or to hospitals/health centers that have those wards if one is not available at the facility of birth. Following a birth, it is important for all mothers and the newborns to receive postnatal health checks to identify complications. Although Ethiopian guidelines for care recommend a health check 24 hours after birth, only 6-17% of women and 13% of newborns had a postnatal health check in the first two days following a birth [12,17,18]. Without postnatal health checks, complications in mothers and/or infants can go undetected and lead to severe disease and death [18].

Unfortunately, some babies develop life-threatening infections after birth. When these infections become systemic and the immune response causes organ dysfunction, these infections are classified as sepsis[19]. Sepsis occurring in the first 28 days of life is considered neonatal sepsis[20]. There are two phases of neonatal sepsis: early-onset sepsis and late-onset sepsis. These two types of infections are not consistently defined in the literature. Early-onset sepsis can be

defined as developing in the first three or the first seven days of life, while late-onset sepsis develops after the first three or seven days of life depending on which early-onset sepsis cutoff is used [21,22]. Babies with neonatal sepsis experience symptoms such as "body temperature changes, breathing problems, diarrhea, low blood sugar, reduced movements, reduced sucking, seizures, slow or fast heart rate, swollen belly area, vomiting, and/or jaundice" [21]. Neonatal sepsis can be caused by a variety of pathogens, including bacteria, viruses, and fungi. Globally, the most common causes of early-onset neonatal sepsis are *Klebsiella* species, *Streptococcus agalactiae*, *Staphylococcus aureus*, and *Escherichia coli* [22,23]. Late-onset neonatal sepsis can also be caused by these bacteria, as well as herpes simplex virus, enterovirus, or *Candida* species [23]. These differences in etiology can be explained by their modes of transmission. Early-onset neonatal sepsis is often caused by transplacental infections from the mother or colonization during the birthing process [23]. Late-onset sepsis is more commonly caused by pathogens in the neonate's environment, including the hands of caregivers and food sources [23]. Surprisingly, studies have found that up to 70% of the pathogens causing neonatal sepsis or other neonatal infections have antimicrobial resistance [22,24]. This poses a threat to providing proper treatment to the neonates. Pre-term or low birthweight babies are at the greatest risk of neonatal sepsis with a three to ten times higher incidence than normal birthweight babies [23]. Additional risk factors for infection specifically in hospital settings include invasive procedures on neonates, contaminated medical devices, overcrowded nurseries, and insufficient sanitary facilities (including access to soap and clean water) [22]. These risk factors help explain why the burden of neonatal sepsis is higher in low- and middle-income countries than in high-income countries [25]. There are an estimated 3 million cases of neonatal sepsis that occur globally each year [26]. Neonatal sepsis, together with neonatal pneumonia, are responsible for approximately 26% of neonatal deaths worldwide [25].

Reducing neonatal mortality is a global priority and has been established as a target for action by the Sustainable Development Goals (Target 3.2) [27]. Progress can be made in reducing neonatal mortality by preventing neonatal sepsis.

While neonatal mortality and sepsis is a concern globally, the risk of mortality is especially high in Ethiopia. In 2019, Ethiopia had an estimated neonatal mortality rate of 28 deaths per 1,000 live births, which is substantially greater than the global rate of 17.5 deaths per 1,000 live births[28]. The global goal for neonatal mortality proposed by the Sustainable Development Goals is to reduce the neonatal mortality rate for all countries to 12 deaths per 1,000 live births by 2030, so considerable progress needs to be made on this front in Ethiopia [29]. Reducing rates of neonatal sepsis has the potential to have a meaningful impact on neonatal mortality in this country. According to three meta-analyses, the estimated prevalence of neonatal sepsis in Ethiopia is 40-50% [30-32]. Approximately 75-77% of these sepsis cases are early-onset sepsis [30,33]. The global risk factors of low birthweight and pre-term delivery hold true in Ethiopia. One study reported that low birthweight babies were 1.42 times more likely to develop sepsis than normal birthweight babies, and pre-term babies had 3.36 times higher odds of developing sepsis than full-term babies [31]. Additional risk factors for neonatal sepsis in Ethiopia have been identified, including a history of urinary tract infection in mothers, babies receiving resuscitation at birth, babies having a low Apgar score, and premature rupturing of the placenta [32,34,35]. Although hospital-level risk factors in Ethiopia have not been strongly established, contaminated medical supplies and environmental surfaces are known causes of infections and outbreaks in healthcare facilities in developing countries [24]. Studies of the etiology of neonatal sepsis in Ethiopia have found *Klebsiella* species, coagulase negative *Staphylococcus*, *Escherichia coli*, *Staphylococcus aureus* to be the main drivers of disease [36-38]. Antimicrobial

resistance is very prevalent in bacterial isolates from neonatal sepsis cases with an observed 57-100% prevalence of resistance to one or more drugs [36,38]. While the high levels of antimicrobial resistance are a threat to effective treatment of neonatal sepsis, one study in Ethiopia found that infections improved in 84% of neonates after treatment [39]. This highlights the complexity of neonatal infections and need for more research in this area.

In order to prevent neonatal sepsis infections, it is critical to understand the pathways through which newborns are being exposed to pathogens. It is hypothesized that early-onset sepsis is mainly caused by exposures during the birthing process, including exposure to pathogens on the mother's body and on medical devices used during delivery [23]. Late-onset sepsis is more likely to be caused by pathogens that are in the environment around the newborns, including the hands of healthcare workers and caregivers, beds and bedding, and medical devices [23]. Therefore, both forms of sepsis have some environmental exposure component that could be targeted by infection prevention programs in healthcare settings to reduce neonatal sepsis. Though data concretely linking environmental exposures to neonatal sepsis is limited, there is some evidence linking contamination on the hands of healthcare workers and mothers to neonatal sepsis and infections in children under 5 years of age [40-42]. Additionally, some outbreaks of HAIs among neonates have been linked to environmental exposures, such as one study where *Pseudomonas aeruginosa* infections among newborns were linked to biofilms on tap water pipes in healthcare facilities in Ireland [43]. There is a growing body of evidence which supports the idea that pathogens, including those that are known to cause neonatal sepsis, can be transmitted from the environment of healthcare facilities to cause healthcare-associated infections (HAIs) [44-48].

Good water, sanitation, and hygiene (WASH) infrastructure and practices can reduce infections by interrupting transmission pathways and making the environments in which people

live cleaner and safer. The importance of WASH in preventing infections is demonstrated by the prioritization of clean water and sanitation in Goal 6 of the Sustainable Development Goals [27]. WASH is often used to improve the conditions of communities or schools, but good WASH infrastructure and practices are also critical for to healthcare settings. The Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP), which is a collaboration between the World Health Organization (WHO) and UNICEF, has set standards for WASH in healthcare facilities and monitors global progress toward the adoption of WASH practices and the achievement of Sustainable Development Goal Targets 6.1 and 6.2 [49]. The JMP reports focus on monitoring five key aspects of WASH in healthcare facilities: water, sanitation, hygiene, waste management, and environmental cleaning [49]. WHO and UNICEF are strongly advocating for improvements in these five key areas of WASH infrastructure in healthcare facilities in order to achieve cleaner environments, provide better quality care, and reduce HAIs. Due to this advocacy, many recommendations for good WASH infrastructure and practices are integrated into infection prevention and control (IPC) guidelines for healthcare facilities.

Chapter 2: Literature Review

Infection Prevention Guidelines for Ethiopian Healthcare Facilities

To understand how newborns are exposed to pathogens which cause neonatal sepsis in healthcare settings, one must begin with the WASH and IPC policies which guide healthcare practices. Neonatal sepsis and other HAIs are an international concern, so the WHO has developed guidelines and principles for healthcare facilities to reduce infection rates [50-54]. The guidelines cover a wide range of topics. Guidelines from 2016 outline what components a health facility's IPC program should include, and a shortened version of this was released in 2019 to showcase the minimum requirements to be prioritized [52,54]. A practical manual to support the implementation of these guidelines was released in 2018 [53]. The WHO also has more specific guidelines for hand hygiene (2009) and waste management (2014) for healthcare facilities [50,51]. While these guidelines are aimed at general IPC practices for all healthcare facilities worldwide, they can be adapted and applied to neonatal care settings to prevent sepsis. In addition to these international guidelines, the Ethiopian Federal Ministry of Health has written their own national IPC guidelines for healthcare facilities which account for the country-level context and resources [55-58]. The 2004 guidelines, which cover many aspects of IPC practices from hand hygiene to medical device cleaning to housekeeping, were updated and expanded in 2012 [55,56]. In 2016 these guidelines were again modified specifically for use by hospital managers, so they cover additional considerations for management and workflow [57]. The Ethiopian Federal Ministry of Health also has guidelines specifically for healthcare waste management written in 2005 [58]. Hospitals in Ethiopia can use both national and international guidelines to develop appropriate IPC practices for their context. These guidelines are described below.

Hand Hygiene

Pathogenic microorganisms can survive on the hands of healthcare workers and be transmitted to patients and cause infections [56]. Therefore, proper hand hygiene is essential to prevent HAIs. Hand hygiene should be performed before and after seeing each patient, after coming into contact with bodily fluids, and after using toilet facilities [56]. The most effective way to clean hands is to wash them with soap and clean running water [50,56]. If piped running water is not available, alternatives such as buckets with taps or pouring water over the hands with a pitcher may work well [55]. Alcohol-based hand sanitizers are also effective in removing pathogens from hands when soap and water are unavailable [50,55]. Single-use towels or personal towels are preferred for drying hands over using a common towel [52,55]. Hand hygiene stations and materials should be available at each point of contact with patients, as well as in toilet facilities [52]. All healthcare personnel should receive periodic training in proper hand hygiene, including techniques for proper cleaning and clear guidance on when hands should be cleaned [50,56]. It is important for hospitals and other healthcare facilities to adopt feasible hand hygiene guidelines and properly train staff on the importance of hand hygiene to prevent the spread of pathogens in healthcare settings.

In addition to keeping the hands of healthcare workers clean, it is also important to keep the hands of caregivers (including family members and other visitors) clean to prevent HAIs in patients. There is evidence to suggest that the handwashing practices of mothers influence neonatal health outcomes [41,42]. Therefore, it is especially important for the treatment and care of newborns to have caregivers with clean hands since they are often touched and held by their mothers. However, this need for clean caregiver hands is not adequately addressed in Ethiopian healthcare guidelines. Education for patients, caregivers, and visitors about IPC practices is

briefly described, but specific topics to be covered (such as hand hygiene) are not suggested [56,57]. Hand hygiene for patients and visitors is recommended for those presenting with symptoms of a respiratory infection, but not for all visitors [56]. Discussions about the need to provide adequate facilities and materials for caregivers to wash their hands is absent from the guidelines.

Water Availability

Hand hygiene is difficult to achieve when water is not consistently available in a health facility. Water is also needed for use in medical devices, for proper cleaning, and for other personal hygiene needs, such as bathing. To allow for proper cleaning and hygiene to prevent infections, the WHO recommends that health facilities should have an adequate quantity of water available in all treatment wards and waiting areas [52,54]. Guidelines from the Ethiopian Federal Ministry of Health require that hospitals have functional water storage containers for when running water is not available, and they should have water tankers to store large quantities of water in case of water supply interruptions [57]. The size of water containers or amount of water to be stored is not specified. More specific guidelines on water storage for Ethiopian healthcare facilities may be beneficial since an estimated 32% of healthcare facilities in the country have access to water within 500 meters of the facility (measured in 2012, does not reflect quantity or quality of the water at the source) [59].

Water Quality

The quality of water that is available in healthcare facilities should also be considered. According to the Ethiopian Federal Ministry of Health, the water should have <1 detectable microorganism (*Escherichia coli* or coliforms) per 100mL of water and should have low turbidity [55,60]. The water should also be free of chemicals and disinfectants [56]. If available tap

water is contaminated with microorganisms, the water can be treated with chlorine or boiled for 5-20 minutes and then filtered [56,57]. The quality of water used in healthcare facilities should be monitored quarterly [56,57]. Safe water should be stored in washed and/or sanitized containers which are labeled as clean water [56]. How long water can safely be stored in containers is not addressed by the Ethiopian guidelines.

Environmental Cleaning

Proper cleaning of the hospital environment is important to keep patients, families, and staff safe and reduce transmission of infection through contact with fomites [57]. According to federal Ethiopian guidelines, all healthcare facilities should have regular cleaning procedures and schedules to be followed by environmental cleaning staff [56,57]. Cleaning staff should be provided with all necessary cleaning supplies (disinfectants, detergents, bleach, mops, brooms, soap, buckets, cloths, and personal protective equipment for staff) to perform their duties [56,57]. Any areas of healthcare facilities where patients are should be thoroughly cleaned twice per day starting from the least soiled areas and moving to the moist soiled areas to contain dirt and pathogens [56,57]. More specifically, patient rooms "should be cleaned daily and right after patient is discharged", and procedure and examination rooms should be cleaned after every procedure/patient [56]. Areas of healthcare facilities where patients do not go (including administrative offices) requiring less stringent cleaning [57]. There are also specific guidelines for laundry services, but they do not cover the cleaning of linens brought from home [56]. Although not addressed by federal guidelines, guidelines from the WHO state that cleaning staff should be trained on proper cleaning techniques, cleaning procedures/schedules, and the importance of cleaning upon hiring and annually thereafter [54]. For hospitals and other healthcare facilities to

maintain proper environmental cleanliness, they need to have adequate cleaning protocols, well-trained and motivated staff, and sufficient supplies to carry out the cleaning.

Waste Management

Proper management of medical waste is critical for preventing nosocomial infections. Medical waste can be contaminated with a variety of pathogens which pose a risk of infection for any person who touches the waste, or surfaces that the waste was in contact with [51,57]. There should be standardized, color coded bins to segregate and collect medical waste appropriately by category: noninfectious, infectious, and sharps [56,57]. The bins should be placed in every patient care area to reduce the distance healthcare workers must travel with waste to dispose of it [51,52,56-58]. This will help prevent surfaces such as counters and floors from being contaminated with the infectious agents. When the bins are full, noninfectious waste will need to be properly disposed of, and infectious waste and sharps will need to be treated to sterilize the waste before disposing of it. These treatments include incineration, steam sterilization, thermal inactivation, chemical disinfection, and secured burial pits [56-58]. The type of treatment selected for use by any given healthcare facility will depend on the resources and space available. The Healthcare Waste Management Directive written by the Ethiopian Food, Medicine, and Healthcare Administration and Control Authority includes a useful checklist which healthcare facilities can use to inspect their waste management systems for effectiveness and efficiency [58]. The proper collection, disposal, and treatment of medical waste protects both healthcare workers and patients from being exposed to infectious agents.

National Initiatives to Promote IPC and WASH

The Ethiopian Federal Ministry of Health started a program in 2014 called the "Clean and Safe Healthcare Facilities Initiative" (CASH). The goal of the program is "to make health facilities clean, safe and comfortable to patients, visitors and staff" focusing on the cleanliness and infrastructure of healthcare facilities [61]. Through the program, all hospitals and some primary health centers receive support in training staff on cleanliness and HAIs, improving facility management, and building WASH infrastructure, such as renovating toilets [7,61]. In addition, the CASH program encourages healthcare facilities to adopt waste management standards and infection prevention and patient safety standards [61]. The CASH program conducts audits of healthcare facilities to identify successes and gaps and offers supportive supervision to support safer practices [7]. Each facility enrolled in the CASH program should have its own CASH team to coordinate with the regional and federal offices and coordinate in-facility efforts [62]. Within the first three years of the program, the CASH program saw a 31% increase in IPC and patient safety practices and a 10% increase in facility management improvement [7].

Outside of healthcare facilities, the Ethiopian Federal Ministry of Health is working to build WASH infrastructure through the One WASH national program. The One WASH program began in 2013 as a collaboration with other sectors of the federal government, NGOs, and UNICEF [62]. The goal of the project is to build community WASH infrastructure, such as water pipes and public latrines [63]. Although this project focuses on building this capacity for communities, a portion of the budget has been allocated specifically for strengthening WASH in schools and healthcare facilities [62]. One WASH has been successful thus far in giving 18.7 million people access to water in just the first four years [64]. This program represents a multi-

million dollar commitment from the federal government to improving WASH conditions in Ethiopia.

Interventions for Infection Prevention in Ethiopian Healthcare Facilities

While guidelines for IPC and WASH lay the foundation for cleanliness and infection prevention in healthcare facilities, it is important to not underestimate the effect of clinical resources and individual behaviors in determining how these guidelines are implemented and adhered to. For the purposes of this project, the behavior and practices of staff were considered to be driven by the combination of personnel knowledge, personnel attitudes, and health facility infrastructure. The IPC programs discussed below were more successful when they used multiple interventions at the same time to promote change. This allowed them to address knowledge, attitudes, and/or infrastructure at the same time to make changes more effectively in the healthcare facilities. There may be some publication bias regarding WASH and IPC interventions because no studies were found that reported null results. Most studies found that every component of their intervention program was successful, at least in the short-term study period.

Hand Hygiene Intervention Studies

Proper hand hygiene is critical for preventing HAIs [56]. The hands of healthcare workers act as transporters for pathogens from unclean surfaces and bodily fluids to susceptible patients [50]. Practicing proper hand hygiene prevents these transmission events and reduces infection rates. Despite the benefits, hand hygiene practices among hospital staff are poor in many places around the world. Studies examining compliance with hand hygiene guidelines in Ethiopia and Sub-Saharan Africa have found healthcare professionals practice proper hand hygiene 5-69% of the

time [65-74]. Many barriers to hand hygiene have been identified that are both structural and behavioral. Structural barriers to hand hygiene include understaffing and overcrowding of patient wards, as well as a lack of access to hand hygiene supplies, including running water and soap [73,75-83]. Another major barrier to hand hygiene is a lack of knowledge about both the risks of disease transmission from poor hand hygiene and about proper hand hygiene practices [66,77,79,81,84-88]. Studies in Egypt, South Africa, and Nigeria found that some healthcare workers have negative attitudes toward hand washing and therefore do not practice hand hygiene often [66,79,88]. Skin irritation was also stated by healthcare workers to be a reason for non-compliance [75,82,85,89]. In many healthcare facilities, these barriers co-occur and reduce hand hygiene practices through multiple pathways.

To combat these barriers to proper hand hygiene, many intervention studies have been conducted which prove the efficacy of hand hygiene promotion programs. Most of these programs use a combination of interventions in a multi-pronged fashion to address both structural and behavioral barriers to hand hygiene with one program. Interventions for structural barriers include establishing alternative handwashing stations, increasing availability and accessibility of soap, water, and towels, and providing alcohol-based hand sanitizer as an alternative to hand washing [67,68,70-72,76,84,89-97]. To address low levels of hand hygiene knowledge, education and training for staff on proper hand hygiene techniques are common [67,68,76,91-93,95,96,98-100]. Many studies also used visual cues, such as signs and posters, to remind healthcare workers when and how to wash their hands [67,68,76,85,92,93,95-97,99]. Other interventions aim to create a culture of hand hygiene promotion within the healthcare facilities by reinforcing ideals at staff meetings, centering practices on patient and provider safety, and providing feedback to staff on hand hygiene compliance and infection rates [67,68,76,85,88,92]. These interventions can be mixed and

matched to fit the resources and needs of a particular healthcare facility. Since hand hygiene interventions are often implemented as part of a package of interventions, additional evidence is needed to evaluate the effectiveness of each intervention on its own.

Waste Management Intervention Studies

Many pathogens can persist in medical waste for days to weeks if left untreated [51]. This poses a risk for HAIs if waste is not handled properly at the point of generation and throughout the facility during collection, treatment, and disposal processes. To promote a safe and streamlined waste management system, all healthcare facilities should have guidelines which are available to and implemented by staff, but this is not always the case [101]. Additionally, many healthcare facilities in low-resource settings do not have adequate supplies and facilities to safely manage waste, including faulty sterilization techniques and scarcity of personal protective equipment [101-110]. Many healthcare facilities in Ethiopia, and in Africa more broadly, have poor waste segregation practices at points of waste generation, which may increase the likelihood that pathogens are present in a patient's environment [101,103-105,107,108,111,112]. This may be a least partially due to a lack of knowledge of proper waste management practices [102,103,106,107,111-115]. It is important to recognize that these barriers to safe waste management do not act in isolation, and multiple barriers may impact waste management practices in a health facility.

While the barriers to proper waste management mentioned above can create health hazards for patients and healthcare workers, they can and have been addressed through various interventions. One such intervention is the development of a waste management committee to oversee the implementation of waste management plans and manage supply needs [116]. To improve waste segregation practices, color-coded bins can be used to collect different types of waste (sharps, infectious, and noninfectious), and signs above the bins help remind healthcare

workers how to properly dispose of different types of waste [109,113]. Both clinical and non-clinical healthcare staff can be trained on the proper use of the bins and on the guidelines for the facility's waste management system to increase knowledge among staff of proper practices [116-118]. Each of these interventions have proven to be effective in improving waste management and promoting patient and staff safety in Ethiopia [109,113,116].

Environmental Cleaning Intervention Studies

Maintaining cleanliness of the hospital environment is essential to prevent infections in vulnerable patients. Contaminated surfaces, including counters, doorknobs, bed rails, and floors, can serve as vehicles for pathogen transmission through direct contact or aerosolization [119]. Therefore, healthcare facilities must have appropriate cleaning protocols which are carried out effectively by environmental cleaning staff. However, not all hospitals have these guidelines available for staff, and they may not be updated to match the most recent national/international cleaning guidelines [120]. Sometimes the cleaning protocols do not address personal equipment, such as cell phones and stethoscopes, and studies have found these objects to be highly contaminated with bacteria [121-123]. Other frequently touched, non-medical items, such as computer keyboards, have also been identified as potential vehicles for bacterial transmission [121]. This highlights the importance of engaging all healthcare facility staff in proper cleaning protocols. Studies in Ethiopia, the Republic of Congo, Benin, and Madagascar have found that many clinical staff members have poor knowledge of proper cleaning techniques and protocols, which may contribute to them having unfavorable attitudes toward cleaning [122,124]. Together, the knowledge and attitudes of healthcare workers and environmental cleaning staff can act as a barrier to performing adequate cleaning behavior.

One way to begin improving environmental cleaning is to use a checklist to conduct an audit and identify gaps in both the protocols and practices [124]. Hospital cleaning procedures should be updated to parallel appropriate guidelines, and all staff should be made aware of these guidelines [122]. Training staff on how to clean medical devices has been shown to be effective in increasing knowledge of sterilization techniques and improving safe cleaning practices [125]. Other studies have developed signage systems to indicate when a patient room needs to be cleaned [126]. Each of these interventions have proven to be effective in improving environmental cleaning in healthcare facilities in Ethiopia and other countries in Sub-Saharan Africa. Research studies examining the availability and use of cleaning supplies, such as disinfectants or mops, were not identified.

Water Treatment Intervention Studies

Having sufficient quantities of clean water in healthcare facilities is vital for infection prevention, yet it is not always available in low-resource settings such as Ethiopia. Two studies in Rwanda found multiple barriers to clean water in healthcare facilities including municipal water shortages, system failures, nonfunctional sinks or water taps, and limited availability of water treatment supplies such as chlorine tablets [127,128]. Some studies also found that even when water treatment supplies were available, they were not always used appropriately [128,129]. This suggests there is an important behavioral component to having clean water in healthcare facilities.

Some studies attempted to address these access issues by providing water treatment supplies to healthcare facilities. The provision of chlorine and other water treatment methods had short-term success but were found to be generally unsustainable years later due to a reported lack of time, needed repairs for water containers, and financial burden [129-132]. Training staff on proper

water treatment protocols was also successful in improving knowledge of safe water quality over time [129]. Future programs should carefully consider how to promote on-site water treatment and improve water quality by using these methods in a sustainable way. To address gaps in water availability, some studies have supplied alternative handwashing and drinking water stations to work around water shortages [129-132]. This was the only type of intervention identified in the literature that addresses water availability in low-resource healthcare facilities.

Hospital Management Structure Intervention Studies

An impactful way to encourage hospital staff to change their behavior regarding infection prevention is to develop an enabling environment to support hygienic behaviors. Having dedicated leadership involved in the day-to-day changes occurring during program implementation drives the changes forward and promotes sustainability of interventions [133,134]. Interpersonal dynamics are also important as psychological safety in the workplace has been associated with promoting change among hospital staff [135].

To develop this structural change for employees, a few interventions have been tested in countries in sub-Saharan Africa that have proven to be effective. Quality improvement collaboratives have been successfully implemented in multiple hospitals [133,136-138]. Some had dedicated, full-time staff to run quality improvement projects while others had current staff dedicate a portion of their time to these committees. As an alternative, one study found success by creating an alliance between leadership and staff to engage all levels in quality improvement. Then, the staff worked together to develop and implement a strategic plan to make lasting changes to their IPC practices [134]. This program and the quality improvement collaboratives were successful because they promoted a culture of change within the facility to encourage staff to perform good IPC practices.

Chapter 3: Projects Aims and Rationale

The Synergy Study (funded from the Emory University Office of the Executive Vice President for Health Affairs with support from the Robert W. Woodruff Health Sciences Center Fund, Inc.) was conducted by researchers at Emory University in Atlanta and at the Emory Ethiopia Office, in collaboration with regional health authorities and hospital staff. The study used a repeated cross-sectional design to examine the relationships between WASH infrastructure and practices, environmental contamination, and neonatal sepsis at two hospitals in the Amhara region of Ethiopia from August 2018 to June 2019. The first hospital, Felege Hiwot, is a large, crowded referral hospital with approximately 450 births per month. The second hospital, Debere Tabor, is a medium-sized general hospital with approximately 260 births per month. To measure the WASH infrastructure and practices in each hospital, an extensive baseline assessment (WASHCon) was conducted using interviews and direct observation [139]. After the baseline assessment, a shortened version of the assessment tool (WASHCon Lite) was used to conduct biweekly assessments of WASH infrastructure and practices in the hospitals (including water availability and overall cleanliness) and collect environmental samples (including water, surface swabs, and handrinse samples) from four wards (labor and delivery, post-natal care, Kangaroo Mother Care, and neonatal intensive care) in each hospital which were analyzed for bacterial contamination. A total of 605 infants were recruited into the study at birth and were followed through the first 28 days of life, and blood samples were collected and analyzed from all suspected cases of neonatal sepsis.

The Synergy Study found that about 1 in 5 newborns developed neonatal sepsis (unpublished). Additionally, the risk of sepsis was 2.4 times higher among low birthweight infants (<2500g) than normal birthweight infants (≥2500g) (unpublished). Antimicrobial

resistance was also found to be an issue with 89% of laboratory isolates from sepsis cases demonstrating resistance to at least one drug. High levels of fecal contamination in drinking water, on the hands of mothers and healthcare workers, and in the environment surrounding the baby were also detected [140]. The WASHCon Lite assessments showed inconsistent cleaning practices, low water availability, and an overall need for improvement in WASH infrastructure and practices in the two study hospitals. Strengthening the WASH and infection prevention conditions in these two hospitals may reduce environmental contamination and prevent neonatal sepsis among newborns.

The results of the Synergy Study raised concern among the research team about the high rates of neonatal sepsis and mortality. Since the rate of mortality in the two study hospitals was more than 50% higher than the average for the Amhara region, it is clear that improvements need to be made in these hospitals to prevent neonatal sepsis and reduce neonatal mortality (unpublished). The research team developed the "Stop Sepsis Now" project, funded by the Emory Global Health Institute, to develop and evaluate interventions which may reduce the prevalence of neonatal sepsis among newborns in Felege Hiwot and Debere Tabor hospitals. The aim of this project is to promote collaboration between the Emory Ethiopia team, hospital directors, and clinicians to review hospital conditions and policies and develop feasible and effective WASH and IPC interventions that will prevent sepsis in newborns.

Chapter 4: Intervention Recommendations for Hospitals

To address the high prevalence of neonatal sepsis detected in two Ethiopian hospitals by the Synergy Study, the Stop Sepsis Now project was developed. The goal of this project is to collaborate with the two study hospitals to identify gaps in IPC and WASH practices that may be contributing to the high levels of neonatal sepsis observed there, and then develop effective strategies to address these issues in a sustainable way. The Stop Sepsis Now project is an action-oriented extension of the Synergy Study. Stop Sepsis Now has five phases. The first phase is to communicate the results of the Synergy Study with hospital administrators, hospital staff, and other stakeholders. The second phase is to conduct a literature review to create an evidence base of potential interventions which were effective in improving IPC practices and WASH infrastructure in similar settings. The third phase is to develop evidence-based recommendations for interventions that could reduce neonatal sepsis in each of the study hospitals. The fourth phase is to use the recommendations and local knowledge to co-design a bundle of interventions which could be used to prevent neonatal sepsis. The fifth phase is to implement the intervention program and monitor the impact on WASH indicators and neonatal sepsis outcomes. The Stop Sepsis Now project is led by researchers at Emory University in Atlanta and researchers at Emory Ethiopia, in collaboration with staff from the study hospitals, regional health authorities, and additional stakeholders.

Phase 1: Communication

The first step to taking action in these two hospitals, and the first stage of this thesis, was to communicate the findings of the Synergy Study with relevant stakeholders. Communication with hospitals and local public health institutions is critical for raising awareness about neonatal sepsis and encouraging action. The Synergy Study results were shared with the study

collaborators, the Ethiopian Federal Ministry of Health, Zonal health departments, other hospitals in the Amhara region, and non-governmental organizations working with the regional health bureau to raise awareness of these important issues.

For Stop Sepsis Now, we facilitated this communication by holding two half-day meetings to present and discuss the findings of the Synergy Study. First, two communication materials were developed to use at these meetings. A PowerPoint presentation was created to show the main results of the Synergy Study (Appendix A). A two-page brief summarizing the results was also created to share with participants at the meetings for them to keep and reference (Appendix B). Researchers from the Emory Ethiopia Office in Bahir Dar hosted these two meetings, one in Bahir Dar and one in Debere Tabor. Participants from each hospital, the Amhara Regional Health Bureau, the Amhara Public Health Institute, and another local university hospital were in attendance. Their occupations included medical directors, regional health directors, pediatricians, department heads, microbiologists, and medical laboratory technologists. The meetings began with the PowerPoint presentation of the results which was followed by a collaborative brainstorming session. Meeting participants were invited to share their ideas for what could be causing neonatal sepsis and what could be improved to prevent these infections.

Written and verbal feedback and ideas from the meeting participants were captured by meeting notes and on written feedback forms (Appendix C). The results of the brainstorming sessions were categorized and summarized to determine which areas of WASH and IPC were of the highest priority to the participants. Most participants were surprised by the high prevalence of antimicrobial resistant bacteria detected in the hospitals, followed by the high rates of neonatal sepsis and contamination of the hands of healthcare workers. Some participants were also

surprised to learn about the contamination of drinking water and environmental surfaces. A majority of participants felt that the issues of environmental contamination and high sepsis rates were not due to inadequate hospital policies, but rather they were due to a lack of adherence to the policies and poor IPC practices. As a result, recommendations to improve IPC practices were the most common feedback received. Other suggested interventions focused on ways to improve the hospital WASH infrastructure and ways to improve treatment for newborns. Participants also mentioned the importance of sharing the results of the Synergy Study more widely with all hospital staff, primary health institutions in the region, and local health authorities. Additional details of these results can be found in Appendix D.

Phase 2: Literature Review

The second phase of Stop Sepsis Now, and this thesis, was developing evidence-based recommendations for changes that could be made in each hospital to reduce the prevalence of neonatal sepsis. This began with a review of relevant literature to identify potential IPC and WASH interventions which have been proven to be effective in increasing safe IPC practices (such as hand hygiene behaviors) and improving environmental cleanliness. PubMed and Global Health databases were searched using strings of key terms. The strings included combinations of a location (Ethiopia or Africa), a setting (healthcare), a topic (waste management, hand hygiene, environmental cleaning, infection prevention, management, water treatment), and either barriers or interventions. The search focused on studies conducted in Ethiopia, sub-Saharan Africa, and/or low resource settings. The relevance and quality of each study was evaluated before being included in the evidence base. A total of 97 articles were selected for use in this review. The results of the literature review were presented in Chapter 2 of this thesis.

Phase 3: Intervention Recommendation Development

The third phase of Stop Sepsis Now, and the final stage of this thesis, was to develop a list of intervention recommendations and resources for the two study hospitals. Once a variety of intervention options were identified in the literature, these options were cross-referenced with the feedback from stakeholders to select interventions that may be feasible for the two study hospitals to implement. Interventions were also selected that would address some of the gaps in infrastructure identified by the Synergy Study. Relevant information from national and international infection prevention guidelines was also considered.

The recommendations were formatted to be easily used by hospital administrators and staff to implement changes at Felege Hiwot and Debere Tabor hospitals. Each potential intervention was classified by the aspect of the hospital it would impact. The targets for change are: hand hygiene practice, hand hygiene infrastructure, hand hygiene for mothers and caregivers, waste management, environmental cleaning, and hospital management/leadership. Within each of these categories, multiple potential interventions were identified with some considerations for the feasibility of implementation and their strengths and weaknesses. A range of options were provided for each category to engage the stakeholders in decision making about what would work well for their context. Additional recommendations for potential collaborations for this work (as suggested by our communication meeting participants) were also included for consideration.

Intervention Recommendations for Debere Tabor General Hospital and Felege Hiwot Hospital to Prevent Neonatal Sepsis

Developed April 2021

Each of the interventions described below have proven to be effective in Ethiopia or other countries in sub-Saharan Africa. Programs were the most successful when multiple interventions were implemented in concurrently.

Hand Hygiene Practice

Intervention	Strengths	Weaknesses
Training for staff ○ On high neonatal sepsis rates, fomite transmission, and need for IPC ○ On proper hand hygiene protocols (proper washing technique and when to wash) ○ On site, in-person with visual tools, eg. Glo Germ lotion (https://www.glogerm.com/) ○ Required for all new staff, plus regular refresher training	Build on current training programs Can help address attitudes toward hand hygiene	Busy staff may not want to comply Staff may not pay attention
Visual cues to encourage practice ○ Updated signs by patient beds and sinks ○ Footprints from toilets to handwashing stations	Signs by sinks already in place Inexpensive	Can be ignored by staff
Supportive supervision and feedback ○ On hand hygiene compliance and neonatal sepsis rates ○ Information sheets, posters ○ Reminders for good practice at staff meetings ○ Possible rewards for good practice or penalties for poor practice	Can impact attitudes and culture of hygiene	Additional work for already busy management staff
Commitment from leadership and staff to promote hand hygiene and a culture of safety ○ Signed contracts of support ○ Verbal commitment to support hand hygiene	Supports a culture change	Takes time to develop, not a tangible change

Resources:

1. The Infection Control Africa Network has a training on basic infection prevention and control practices for clinical healthcare workers. This course is 5 days, in-person. The training covers proper hand hygiene, as well as transmission routes for common pathogens and considerations for water and the hospital environment. This training is appropriate for clinical staff or leadership.
   Access online: http://www.icanetwork.co.za/wp-content/uploads/2019/01/2019-Basic-IPC-for-HCW.pdf
2. The World Federation for Hospital Sterilization Sciences has a written module on personal hygiene, including hand hygiene, for healthcare workers. This is a 13 page document which could be used or modified as part of other verbal communications. It is appropriate for clinical staff.
   Access online: https://wfhss.com/wp-content/uploads/wfhss-training-1-01_en.pdf
3. The World Health Organization has developed on online module which summarizes their guidelines for hand hygiene. The module covers appropriate hand hygiene techniques and methods for implementation. This training may be appropriate for clinical staff or leadership looking to improve hand hygiene in a healthcare facility.
   Access online: https://openwho.org/courses/IPC-HH-en

Hand Hygiene Infrastructure

Intervention	Strengths	Weaknesses
Make alcohol-based hand sanitizer more widely available ○ Can be made on site using WHO guidelines ○ Established stations and/or individual bottles to staff	Independent of water availability Convenient	Potential cost Requires staff to produce the produce if made on site, or to order the product. Also requires time of staff to refill stations or personal bottles. May have low compliance on its own
Alternative hand hygiene stations when running water is not available ○ Bucket with spigot or foot pedal ○ Placed in accessible locations that do not clutter working areas ○ Should be made available at points of care, in bathrooms, and in food preparation areas	Functional when piped water is not	Uses more resources, including clean water and staff time to keep water containers full Requires additional cleaning protocols

Committed supply of soap at sinks ○ Liquid soap dispensers prevent theft compared to bar soap	Ensures proper hand hygiene is possible Constant availability helps build habits of proper hand hygiene	Uses financial resources and requires space in a budget Needs a management system to make sure soap is ordered and stocked at sinks Dependent on supply chain
Committed supply of individual towels for hand drying ○ Towels can be disposable or washed and reused	Promotes proper hand hygiene Prevents cross-contamination from shared towels	Uses financial resources Requires additional cleaning protocols Needs a management system to make sure towels are available and dirty towels are collected for cleaning Dependent on supply chain
Repair existing handwashing stations to make them more functional ○ Repair faucets and pipes ○ Contract with local plumber for repairs ○ Use of robust sink designs and hardware for taps and handles	Leverages existing infrastructure Does not take up more physical space like alternative hand washing stations would	Contracts with plumbers can be costly Need to develop a system to report sinks that need to be repaired
Resources: 1. The World Health Organization has guidelines for how to make alcohol-based hand rubs on-site in healthcare facilities. This can be more cost effective than buying manufactured hand rub products. This is appropriate for decision-making leadership and staff that would produce the hand rub. Some hospitals in Addis Ababa are already producing alcohol-based hand rubs and could provide advice to other Ethiopian hospitals on where to procure the necessary supplies and how to implement this. Access online: https://www.who.int/gpsc/5may/Guide_to_Local_Production.pdf 2. Happy Tap is an organization that produces alternative hand hygiene stations. They have guidance that includes points to consider when building alternative hand		

hygiene stations, including the size of the water tank and where to place them in a healthcare facility. This is a useful resource for leadership wanting to learn more about alternative hand hygiene stations. Access online: https://happytap.net/solution/hcf/

Hand Hygiene For Mothers and Caregivers

Intervention	Strengths	Weaknesses
Education on proper hand hygiene ○ Including proper techniques and importance for infection prevention ○ Handouts with visual instructions provided to each mother/caretaker ○ Demonstration and discussion for groups of mothers ○ On site, in-person with visual tools, eg. Glo Germ lotion (https://www.glogerm.com/)	Keep mothers' hands clean Help prevent infections developed at home Could be bundled with other maternal education about newborn care practices	Time and resources to develop and distribute information
Regular cleaning and maintenance of patient bathroom facilities	Helps mothers keep their hands clean, especially important in the KMC ward	Requires dedicated staff Requires specialized cleaning protocols Cost of cleaning supplies and dependency on supply chain
Sinks in patient wards that are dedicated for use by mothers and caregivers ○ Use of robust sink designs and hardware for taps and handles that can withstand high use and abuse ○ Supplied with soap	Helps mothers keep their hands clean, especially important in the KMC ward	Uses financial resources Needs a management system to make sure soap is ordered and stocked at sinks
Provision of alcohol-based hand sanitizer ○ Individual bottles for each family ○ Patient sanitizing stations ○ Can be made commercially or on-site	Functional when running water and soap are not available	Uses financial resources Stations could take up space in already crowded wards

Installment of alternative hand hygiene stations specifically for mothers and caregivers ○ Bucket with spigot or foot pedal ○ Placed in accessible locations that do not clutter working areas ○ Should be made available at points of care, in restrooms, and in food preparation areas	Functional when piped water is not	Uses more resources, including clean water and staff time to keep water containers full Requires additional cleaning protocols
Resources: 1. The World Health Organization has graphics which demonstrate proper hand hygiene with alcohol-based hand rubs or handwashing with soap and running water. The document is targeted to clinical healthcare staff, but the visuals could be adapted for use with mothers and caregivers. Access online: https://www.who.int/gpsc/5may/Hand_Hygiene_Why_How_and_When_Brochure.pdf?ua=1		

Waste Management

Intervention	Strengths	Weaknesses
Training for staff ○ On proper waste segregation and benefits for clinical staff ○ On proper handling and treatment protocols for environmental staff ○ Make all guidelines available to staff after training	Ensures all staff know proper procedures Support positive attitudes about cleaning	Time to update training materials Time from busy staff
Visual cues ○ Color-coded bins for waste disposal in patient rooms ○ Posters/signs near waste bins with information on how to properly segregate waste	Reminders throughout the day of what to do encourage behavior change Make waste segregation simple	Can be ignored by staff

Ensure waste treatment facilities are adequate ○ Clear plan of action from waste generation to treatment to final disposal ○ Waste treatment facilities should be functional and prevent occupational exposures	Ensure hazardous waste is decontaminated to prevent occupational exposure	Potential cost of incinerator or contract for waste collection and disposal service Time
Resources: 1. The World Health Organization has an online training course to cover the basics of healthcare waste management. This includes how to segregate and move contaminated waste through a healthcare facility, and how to reduce occupational exposure risk. This training is appropriate for leadership looking to learn more about waste management standard practices. Access online: https://openwho.org/courses/IPC-WM-EN 2. The World Health Organization has additional written materials about healthcare waste management. There are 25 different documents with many topics from waste management planning to storage and treatment procedures. These are most appropriate for leadership looking to learn more about waste management. Access online: https://www.who.int/water_sanitation_health/facilities/waste/training_modules_waste_management/en/		

Environmental Cleaning

Intervention	Strengths	Weaknesses
Training for environmental staff ○ On proper cleaning protocols and expectations for each day ○ Include explanations about the importance of proper cleaning, and neonatal sepsis rates ○ Upon hiring and annual refreshers ○ Tailored to each hospital's structure	Improve knowledge and attitudes about proper cleaning practices Reinforces positive behaviors	Busy staff may not want to comply Staff may not pay attention
Checklist for cleaning every surface ○ Including information on proper disinfection ○ Include floors, counters, doors, medical devices, water storage containers ○ Include how often each should be cleaned (1x or 2x per day)	Make sure all surfaces get cleaned Information about how to properly clean an item is readily available	Some items could be missed if rushing through work

Signage system to indicate when a room needs cleaning ○ Card that is red on one side, green on the other. Clinicians flip the card to red at key times, such as when a patient is discharged, to indicate that a room needs to be cleaned. Environmental cleaning staff flip the card back to green after cleaning.	Increase communication between clinical and environmental staff Make sure rooms get cleaned between patients to prevent cross contamination	Forgetfulness may cause it to not be used
Provision of adequate cleaning supplies ○ May be separate for each ward to reduce cross contamination ○ Disinfectants, brooms, mops	Allows environmental staff to properly perform duties	Uses financial resources and requires a dedicated line in a budget Dependence on supply chain for items that need regular replacement Needs an inventory management system to make sure supplies are ordered and kept available
Provision of personal protective equipment for environmental cleaning staff ○ Including gloves, uniforms, aprons, and boots	Allows environmental staff to properly perform duties Prevents cross-contamination	Uses financial resources and requires a dedicated line in a budget Dependence on supply chain for items that need regular replacement Needs an inventory management system to make sure supplies are ordered and kept available

Monitoring and feedback ○ On cleaning practices and infection rates ○ Written reports given to staff members ○ Mentioned at staff meetings ○ Positive reinforcement and rewards for safe behaviors	Reinforces positive behaviors Can improve attitudes and motivation for environmental staff if they see success	Time to produce reports and monitor cleaning practices
Clear protocol for linen cleaning and replacement	Prevent transmission of drug-resistant organisms from home to the baby and to the community at discharge	May have difficulty with compliance from the mothers/caregivers Requires financial resources for laundry equipment and supplies, dedicates space, and personnel
For Debere Tabor, hire additional cleaning staff ○ FH has 1 cleaning staff per 4.5 babies, DT has 1 cleaning staff per 7.7 babies (monthly)	Ensures environmental staff have the time and capacity to improve cleaning procedures	Cost Additional training and cleaning resources needed to support new staff

Resources:

1. The Training in Environmental Hygiene and Cleaning in Healthcare (TEACH CLEAN) package is a training program for environmental cleaning staff in healthcare facilities. The program teaches staff about the importance of clean environments and how to improve cleaning practices. This training was developed to explain daily activities for cleaners and is appropriate to use with cleaning staff. TEACHCLEAN was developed by The Soapbox Collaborative and is distributed by the London School of Hygiene and Tropical Medicine.
   Access online: https://www.lshtm.ac.uk/research/centres/march-centre/soapbox-collaborative/teach-clean
2. The Infection Control Africa Network offers in-person, 5-day trainings on decontamination and sterilization. The courses cover material from choosing appropriate disinfectants to evaluation of cleaning methods. The courses are offered in basic, intermediate, and advanced levels. These trainings may be appropriate for leadership or cleaning staff.
   Access online: http://www.icanetwork.co.za/wp-coAntent/uploads/2019/01/2019-Basic-CSSD-Course.pdf

3. The World Federation for Hospital Sterilization Sciences has a written module on cleaning, disinfection, and sterilization. This is a 30 page document containing information about different types of disinfectants and sterilizing methods. It is appropriate for cleaning staff.
   Access online: https://wfhss.com/wp-content/uploads/wfhss-training-1-03_en.pdf
4. The World Health Organization has an online training regarding proper cleaning of medical devices. This training goes through effective cleaning processes for these medical supplies.
   Access online: https://openwho.org/courses/IPC-DECON-EN
5. The World Health Organization has a training which covers the standard procedures for environmental cleaning and disinfection. This may be appropriate for cleaning staff.
   Access online: https://openwho.org/courses/IPC-EC-EN
6. The United States Centers for Disease Control and Prevention and the Infection Control Africa Network have created a guidance document with information about environmental cleaning in resource-limited settings. It outlines procedures for cleaning programs and includes a discussion of cleaning supplies and equipment.
   Access online: https://www.cdc.gov/hai/prevent/resource-limited/environmental-cleaning.html

Hospital Management/Leadership

Intervention	Strengths	Weaknesses
Update institutional IPC and WASH policies to ensure they follow relevant national and international guidelines	Set a strong foundation to act on Evidence-based guidelines should have the highest impact	Time Reliance on sporadic internet access
Commitment from leadership to promote the chosen interventions and a culture of cleanliness ○ Written and signed contracts ○ Verbal commitments to cleanliness ○ Monthly check-in meetings to discuss successes and barriers ○ Develop rewards and recognition for strong-performing staff	Change cultural norms to promote cleanliness	Requires sustained motivation from staff which can be difficult to maintain
Mentorship and role modeling of proper practices	Change cultural norms to promote cleanliness	Leadership may be too busy to implement

Develop a strategic plan for IPC changes and develop alliance with staff to implement the changes ○ Regular meetings to discuss successes and challenges ○ Develop rewards and recognition for strong-performing staff	Sets a clear path for infection prevention Adds motivation for staff to work on these issues as a team Change cultural norms to promote cleanliness	Having a plan does not immediately translate to action
Implement a water contingency plan ○ Includes how and when to store water ○ How stored water can be used	Adds consistency in actions when water is not available Promote clean water storage	Needs leadership to make sure the plan is followed
Activate infection prevention and control committees and quality improvement committees to oversee and enforce changes ○ Monitor neonatal sepsis rates and provide feedback to clinical and environmental staff ○ Monitor hospital conditions (microbiological monitoring of environmental contamination, visual inspections with checklists, etc.) through systematic, periodic audits to identify gaps ○ Given the authority to develop and implement changes ○ Alternatively, train one person to be a quality improvement specialist to lead these operations	Interdisciplinary Adds responsibility to ensure these practices are carried out Resource for staff to answer questions and gain information Can promote culture of cleanliness	Needs strong organization Could be difficult to give authority to make changes Auditing will require human and financial resources and will need oversight and accountability
Ensure appropriate personal protective equipment is available for all staff ○ Gloves, gowns, etc.	Prevent cross-contamination between patients	Cost of resources

Apply findings from CASH audits and regular monitoring to identify gaps and focus on areas of need	Use information to focus changes on high-impact areas	Need a person or team tasked with doing this with time/capacity in their workflow

Resources:

1. The Directorate General of Health Services of Bangladesh has a manual on the 5S program for hospital organization. The 5 S's are sort, straighten, shine, standardize, sustain. These are guiding principles for standardization and cleanliness for medical supplies and waste. The manual is appropriate for leadership that structure the hospital environment.
   Access online:
   https://www.jica.go.jp/project/bangladesh/002/materials/ku57pq00001gtcss-att/Implementation_of_5S_in_Hospital-Setting.pdf
   Presentation on the use of 5S in an American hospital:
   https://www.slideshare.net/PabloCrdenasOrlandin/5s-in-hospitals-training-session
2. The Infection Control Africa Network has a course called "Train-the-Trainer" which provides information about how to effectively train others on infection prevention and control practices. The course covers information on adult learning styles, presenting infection prevention information, and communication skills. This training is appropriate for leadership or staff members that will conduct trainings for other staff. The course has 5 days of in-person training and 9 weeks of self-study.
   Access online: http://www.icanetwork.co.za/wp-content/uploads/2019/01/2019-TTT-course.pdf
3. The World Health Organization has an online training for how to develop an effective infection prevention and control program for a healthcare facility. This training is designed for leadership to learn more about what infection prevention programs should include and how to promote safe practices among staff.
   Access online: https://openwho.org/courses/IPC-CC-MMIS-EN
4. The World Health Organization has a training for improving the skills of infection prevention program managers. The training covers project management skills, risk assessments, and implementation strategies.
   Access online: https://openwho.org/courses/IPC-leadership-EN
5. Save the Children and USAID Maternal and Child Survival Program have developed the Clean Clinic Approach. This is a method to guide healthcare facilities to develop WASH-related goals that align with the goals of the appropriate national ministries of health.
   Access online: https://www.mcsprogram.org/resource/clean-clinic-approach-brief/

Collaboration

Intervention	Strengths	Weaknesses
Share information about successful/ unsuccessful policies and practices with ○ Primary care health institutions ○ Health Extension program ○ Amhara Regional Health Bureau ○ Should include all hospital staff, such as clinicians and environmental cleaning staff ○ National and regional professional organizations of clinicians, nurse-midwives, hospital directors, etc.	Sharing with and learning from other organizations can promote innovation and motivation and ultimately improve care in the region	Requires leadership Time for regular meetings Requires time and personnel to prepare appropriate communication Requires resources for communication – via email, teleconference, in-person meetings, or printed newsletters

Chapter 5: Discussion

The recommendations for Felege Hiwot and Debere Tabor presented above were developed as a tool to guide these two hospitals as they make changes to address the high prevalence of neonatal sepsis in their facilities. The next step for the Stop Sepsis Now project is to provide these recommendations of potential interventions to the hospital administrators and staff to facilitate a discussion about which interventions are feasible given the context and resources, and how to take action. Emory researchers, from Atlanta and Bahir Dar, will work with the hospitals and interested stakeholders to co-develop a quality improvement program to address neonatal sepsis. The program will be designed by choosing a few of the potential interventions described in the recommendations in Chapter 4 to be adapted as appropriate and implemented as a bundle. This bundle will be piloted and monitored by the Stop Sepsis Now team. If the pilot program is successful in reducing environmental contamination, hand contamination, and neonatal sepsis morbidity and mortality, the program may be scaled up and implemented in additional hospitals in the Amhara region.

Each of the potential interventions presented in Chapter 4 has been previously described in the scientific literature as a means of achieving positive change for cleanliness in healthcare settings. The success of the interventions was measured differentially by each study. The studies used a mixture of self-reported behavior, observation of behavior, observation of the healthcare facility environment, knowledge tests of staff, surveys of staff, microbiological analysis of hand and environmental contamination, and microbiological and chemical tests of water samples to determine the impact of each intervention. While these studies did not specifically aim to reduce neonatal sepsis, they did measure significant improvements in staff hygiene behaviors and environmental sanitation as a result of the interventions. Since neonates can develop infections

after exposure to pathogens in their environment, the recommended interventions for the two study hospitals are expected to improve the hygiene and sanitation infrastructure and practices of the hospitals and therefore reduce the prevalence of healthcare-associated neonatal sepsis.

The strength of the recommendations presented above comes from the evidence-based nature through which they were developed. The results of the Synergy Study were used to identify specific areas of weak WASH infrastructure (eg. non-functional sinks), contamination (eg. hands of clinicians and mothers, surfaces, and bed linens in contact with newborns), and poor IPC practices (eg. use of tapwater for medical devices). By selecting interventions that target these known gaps in sanitation and hygiene, a program using these interventions is more likely to be successful in these Amhara hospitals. The recommendations were also based on the discussion between participants at the communication meetings in Bahir Dar and Debere Tabor. These participants have the local knowledge and experience to determine which areas of infection prevention should be focused on and how to do that effectively. A literature review was used to support and further refine these suggested interventions. A large body of peer-reviewed journal articles was analyzed and summarized to determine the effectiveness of specific types of interventions. Most of the interventions were shown to be effective by multiple studies, which shows promise for their success if implemented in the two study hospitals. By drawing on local knowledge, peer-reviewed literature, and insight gained from the Synergy Study, the recommended interventions are well supported and should lead to an effective and sustainable quality improvement program.

Despite multiple sources of data used in the development of the proposed intervention recommendations, they are not without limitations. The main limitation is that a comprehensive formative research study to understand how these hospitals operate was not conducted. There

was some operational information collected in the baseline assessment of each facility for the Synergy Study, but there were some gaps. Information regarding staff behavior, such as how toilet facilities are cleaned or how hand hygiene is performed when running water is unavailable, was not collected. Performing observation of these practices and conducting interviews with staff members would have provided useful information to contextualize the recommendations and tailor them to the unique circumstances at each hospital. Another limitation of the evidence used to develop the recommendations is that most of the studies identified through the literature review did not evaluate long-term impacts of the interventions that they evaluated. Most studies evaluate the results a few weeks or months after the interventions are implemented. Very few studies measure the impact or continuation of the interventions years after they were initially implemented, so evidence supporting the sustainability of the recommended interventions is limited.

Though these recommendations were designed specifically for Felege Hiwot and Debere Tabor hospitals, they are relevant for other hospitals in the Amhara region that have similar infrastructure and cultural context. The evidence-based recommendation development serves as a model for the first stage of program development for any healthcare facility. These specific recommendations may become outdated as additional programs and literature are published, but the recommendations can serve as a resource for the two study hospitals for years to come.

In addition to the local implications of this project, much can be learned for national programs. Evidence from the Synergy Study demonstrated that both Felege Hiwot and Debere Tabor hospitals had high levels of environmental contamination, antimicrobial resistant bacteria, and neonatal sepsis. Even though Debere Tabor Hospital is enrolled in the CASH Initiative, the environmental contamination and risks to neonatal health were similar, if not greater, than at

Felege Hiwot Hospital, which was not enrolled in the CASH program at the time of the study. National initiatives, such as the CASH Initiative, should require regular audits and monitoring of health facilities that they work with, and then use those results to provide feedback to the facilities to promote continuous quality improvement and tailor the program to each facility.

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Appendix

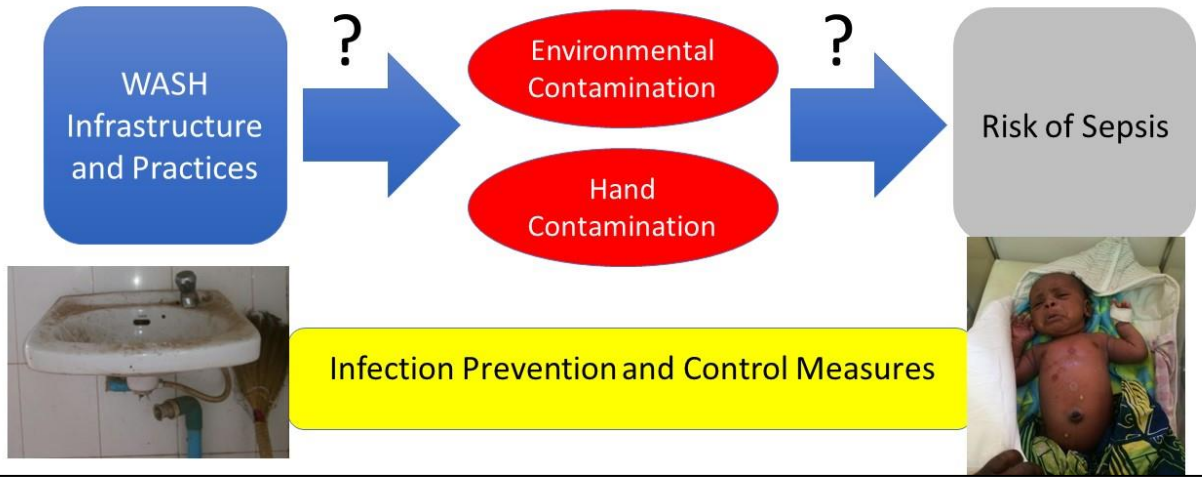
Appendix A. Presentation of Synergy Study Results

Synergy Study

Measuring the Impact of Water, Sanitation, and Hygiene on Neonatal Sepsis in Two Hospitals in Amhara, Ethiopia

Emory Ethiopia, Amhara Public Health Institute, Amhara Regional Health Bureau, & Emory University

What is the Health Impact of Poor WASH in Healthcare Facilities?



Study Objectives

1. What is the incidence of neonatal sepsis in two study hospitals in Ethiopia?
   - How does this incidence compare between low birth weight and normal birth weight infants?
   - How does this incidence compare between infants in the post-natal wards, the Kangaroo Mother Care (KMC) wards and the neonatal intensive care units (NICUs)?
2. What are the etiologic agents of neonatal sepsis in two study hospitals in Ethiopia?
   - Are there differences in the etiologic agents of neonatal sepsis by hospital and by ward?
   - What are the antimicrobial resistance patterns of bacterial agents detected in blood specimens from neonatal sepsis cases and how do these vary by hospital and by ward?
3. Do hospital maternity wards and neonatal intensive care units (NICUs) with limited WASH infrastructure and practices have hand contamination and environmental contamination with pathogens known to cause neonatal sepsis (e.g. *E. coli*, *Staphylococcus aureus*, *Klebsiella pneumoniae*)?
   - Which sites in the wards are most frequently contaminated?
   - How do WASH conditions and environmental contamination in maternity wards and NICUs vary over time?
4. Are infants who receive care in hospital maternity wards and NICUs with environmental contamination at greater risk of healthcare-acquired neonatal sepsis compared to infants in maternity wards and NICUs without environmental contamination?
   - How does this risk compare between low birth weight and normal birth weight infants?

Two Contrasting Study Hospitals in Amhara Region, Ethiopia

Felege Hiwot

- Referral hospital
- Large; 450 births/month
- Crowded
- Reported prevalence of neonatal mortality = 13.3% (Tewabe et al., 2018)

Debere Tabor

- Regional hospital
- Medium; 260 births/month
- New maternity and post-natal building
- Recognized as a CASH ("Clean and Safe Hospital") hospital by Ethiopian Ministry of Health

Methods

- Subject recruitment and follow up (total n = 605)
  - Recruitment at hospitals at time of birth
  - Follow-up visits/phone calls to determine neonatal health status
- Clinical specimen collection and microbiological analyses from infants with suspected sepsis
  - Identify suspected sepsis cases at PNC, NICU, or KMC
  - Blood samples collected and analyzed for pathogens and AMR (Standard of Care diagnosis and treatment) by regional government health laboratory (n=187)
- Assessment of hospital WASH conditions (WASHCon)
  - Beginning of study and biweekly (WASHCon Lite) (n=21)
- Structured observations in maternity and neonatal wards
  - Beginning of study to inform environmental sampling
  - Post-natal ward, Kangaroo Mother Care (KMC) rooms, Neonatal Intensive Care (NICU)
- Environmental sample collection from maternity and neonatal wards and microbiological analyses
  - Biweekly (n=442)
  - *E. coli, total coliforms, Staphylococcus aureus,* and *Klebsiella*

Sepsis Prevalence and Etiology

Lab-Confirmed Neonatal Sepsis Incidence per 1000 Births by Facility

Facility	Incidence	Incidence Rate Ratio
Debere Tabor	236	1.51
Felege Hiwot	156	

599 eligible neonates

31% Probable sepsis*

19.9% of all 599 eligible neonates are lab-confirmed Sepsis (+)

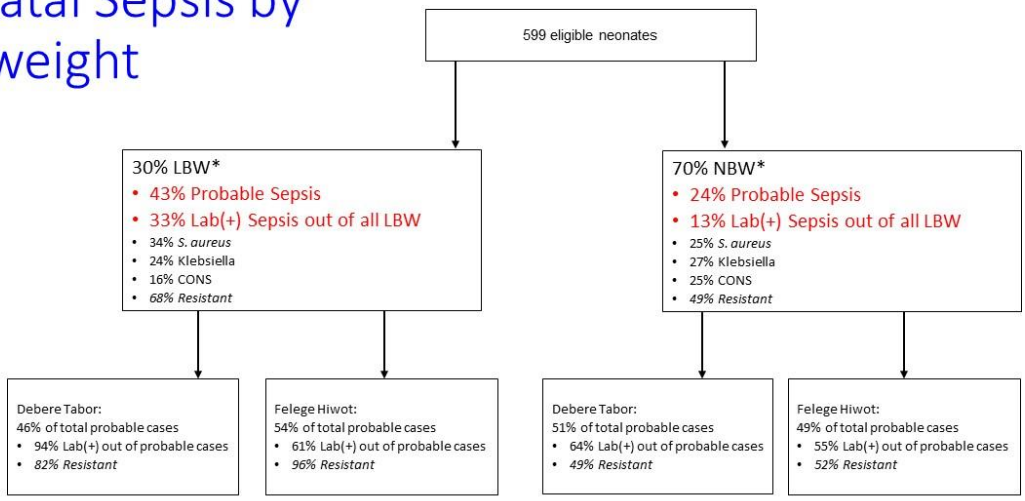
68% of probable sepsis cases were laboratory-confirmed to have sepsis
- ***29% S. aureus***
- 27% *Klebsiella*
- 19% *CONS*

Debere Tabor:
78% laboratory-confirmed sepsis (+) out of all probable cases at DT
- **38% *S. aureus***
- 16% *Klebsiella*
- 12% CONS

Felege Hiwot:
60% laboratory-confirmed sepsis (+) out of all probable cases at FH
- **40% *Klebsiella***
- 19% *S. aureus*
- 27% CONS

* Probable sepsis = any infants that the clinicians suspected of sepsis and submitted a blood culture for

Neonatal Sepsis by Birthweight



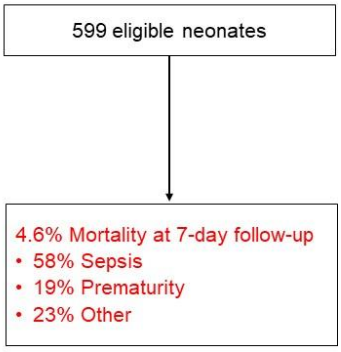
*Birthweights
<2500g = low birth weight (LBW)
≥2500g = normal birth weight (NBW)

Mortality Outcomes

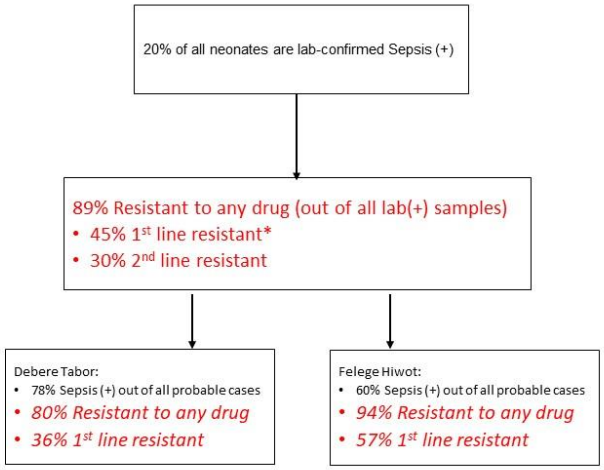
High neonatal mortality rate at 7 day follow up
- 48.9 per 1000 live births
- 27.2 per 1000 live births in Sub-Saharan Africa at 30 days

By birthweight (per 1000 live births)
- 149.7 low birth weight (<2500 grams)
- 2.5 normal birth weight (≥ 2500 grams)

By facility (per 1000 live births)
- 76.9 Felege Hiwot
- 7.8 Debere Tabor



Antimicrobial Resistant Sepsis Prevalence



71% of all resistance is to one of five drugs:
- Gentamicin
- Ceftriaxone
- Augmentin
- Ciprofloxacin
- Sulfamethoxazole

These are predictive of mortality at Felege Hiwot.

*1st line therapy = ampicillin and/or gentamicin

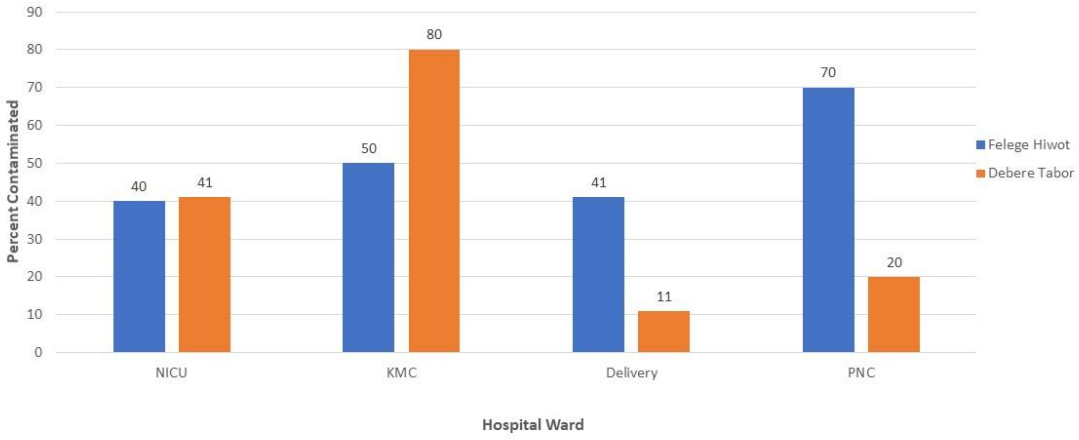
Environmental Conditions: Hand Hygiene

WASHCon Lite Assessments by Hospital and Ward

		Felege Hiwot (N=7)				Debere Tabor (N=12)			
	Ward	NICU ^	KMC†	Delivery	PNC§	NICU ^	KMC†	Delivery	PNC§
		N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Hand Hygiene									
Hand Hygiene Station (Clinicians/Staff)		6 (86)	5 (71)	6 (86)	2 (29)	12 (100)	12 (100)	8 (67)	9 (75)
Water and Soap Available		6 (86)	1 (14)	2 (29)	0 (0)	7 (58)	9 (75)	3 (25)	2 (17)
Hand Hygiene Station (Patients/Caregivers)		6 (86)	6 (86)	4 (57)	3 (43)	10 (83)	10 (83)	6 (50)	7 (58)
Water and Soap Available		1 (14)	0 (0)	1 (14)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Hand Hygiene Promotion Materials Visible		3 (43)	0 (0)	2 (29)	0 (0)	12 (100)	12 (100)	11 (92)	12 (100)

Handrinse Results

Percent of **Handrinse Samples** with Target Bacteria^ by Hospital and Ward*



^ Target Bacteria = Positive for *E. coli, S. aureus* or other coliforms (non-*E. coli* coliforms)

*Wards: NICU = Neonatal Intensive Care Unit, KMC= Kangaroo Mother Care, PNC = Post-natal Care

Handrinse Results Continued

% *E. Coli* Contaminated Handrinse Samples by Sex and Occupation/Role

***E. coli*^ Contaminated Hand Demographics by Hospital**

	Felege Hiwot (n=5)	Debere Tabor (n=13)
	%	%
Male Sex	20	8
Female Sex	80	92
Doctor	20	8
Nurse	20	38
Midwife	20	8
Mother	40	38
Caregiver	-	8

*Repeated assessments by ward over time

^Both membrane filtration and compact dry plate tests are included

§ Limit of detection is <1 CFU per pair of hands for Membrane Filtration

† Limit of detection is <1 CFU per 1 mL for Compact Dry Plate

At Felege Hiwot, 1 doctor, 1 nurse, 1 midwife, and 2 mothers had hands contaminated with *E. Coli*

At Debere Tabor, 1 doctor, 5 nurses, 1 midwife, 5 mothers, and 1 caregiver had hands contaminated with *E. Coli*

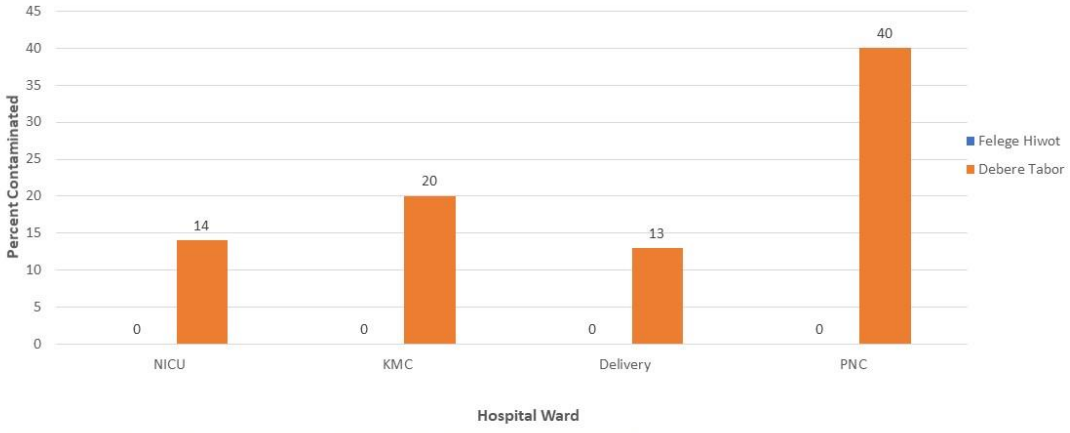
Environmental Conditions: Water

WASHCon Lite Assessments by Hospital and Ward

	Felege Hiwot (N=7)				Debere Tabor (N=12)			
Ward	NICU ^	KMC†	Delivery	PNC§	NICU ^	KMC†	Delivery	PNC§
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Water								
Piped water	7 (100)	7 (100)	7 (100)	4 (57)	12 (100)	12 (100)	12 (100)	11 (92)
Functional Piped Water	7 (100)	6 (86)	7 (100)	3 (43)	12 (100)	12 (100)	5 (42)	8 (67)
Water Available	4 (57)	5 (71)	5 (71)	1 (14)	12 (100)	12 (100)	11 (92)	11 (92)
Treated Water Available	0 (0)	0 (0)	0 (0)	0 (0)	12 (100)	12 (100)	11 (92)	11 (92)
Ward Water Storage	2 (29)	1 (14)	2 (29)	4 (57)	10 (83)	11 (92)	11 (92)	11 (92)
Ward Water Storage (Treated)	0 (0)	0 (0)	0 (0)	0 (0)	12 (100)	12 (100)	9 (75)	11 (92)

Drinking Water Results

Percent of **Drinking Water Samples** with Target Bacteria^ by Hospital and Ward*



^ Target Bacteria = Positive for *E. coli, S. aureus* or other coliforms (non-*E. coli* coliforms)

*Wards: NICU = Neonatal Intensive Care Unit, KMC= Kangaroo Mother Care, PNC = Post-natal Care

Environmental Conditions: Environmental Cleanliness

WASHCon Lite Assessments by Hospital and Ward

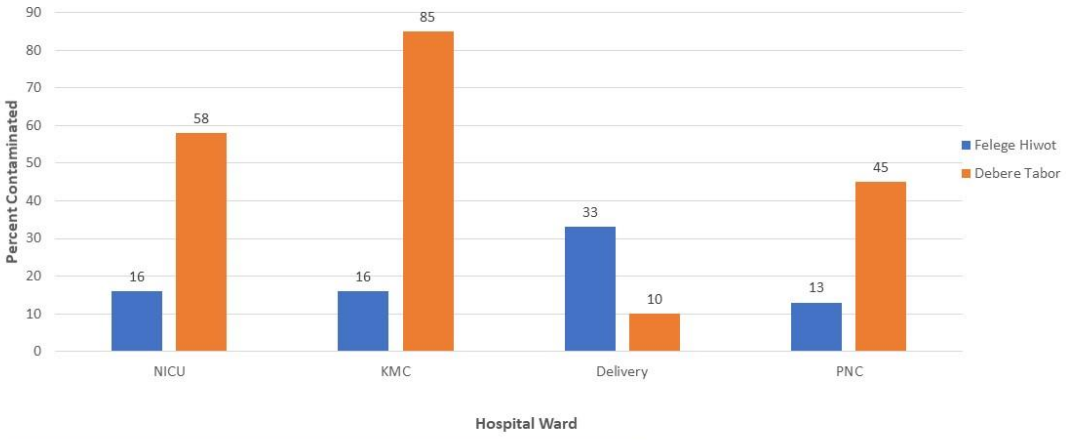
	Ward	Felege Hiwot (N=7)				Debere Tabor (N=12)			
		NICU ^	KMC†	Delivery	PNC§	NICU ^	KMC†	Delivery	PNC§
		N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
Infection Prevention and Control (IPC)									
Gloves Available		7 (100)	4 (57)	7 (100)	6 (86)	11 (92)	12 (100)	12 (100)	12 (100)
Disinfectant Available		6 (86)	3 (43)	7 (100)	5 (71)	12 (100)	12 (100)	11 (92)	11 (92)
Clean Delivery Surface		-	-	5 (71)	-	-	-	5 (42)	-
Control Access Point for Ward Entry		7 (100)	-	-	-	12 (100)	-	-	-
Control Access Point Enforced		5 (71)	-	-	-	12 (100)	-	-	-
Personal Protective Equipment Required		6 (86)	-	-	-	7 (58)	-	-	-
Hand Washing Required		0 (0)	-	-	-	0 (0)	-	-	-
Fresh Gloves upon Entry		1 (14)	-	-	-	0 (0)	-	-	-
Hand Re-contamination upon Entry		0 (0)	-	-	-	0 (0)	-	-	-
Environmental Cleanliness									
Safely Segregated Waste (3 labeled bins)		3 (43)	2 (29)	5 (71)	2 (29)	3 (25)	2 (17)	0 (0)	0 (0)
Ward Visibly Clean (Dust and Soil)		6 (86)	7 (100)	7 (100)	7 (100)	10 (83)	11 (92)	2 (17)	1 (8)
Ward Spill Free (No spills of bodily fluids)		6 (86)	6 (86)	7 (100)	6 (86)	12 (100)	12 (100)	6 (50)	4 (33)
Ward Floors Visibly Clean		7 (100)	7 (100)	7 (100)	7 (100)	8 (67)	12 (100)	2 (17)	1 (8)
Staff Toilet		7 (100)	7 (100)	7 (100)	6 (86)	12 (100)	12 (100)	12 (100)	12 (100)
Staff Toilet Visibly Clean		7 (100)	5 (71)	6 (86)	6 (100)	10 (83)	9 (75)	11 (92)	11 (92)
Patient Toilet		7 (100)	7 (100)	7 (100)	7 (100)	12 (100)	12 (100)	12 (100)	12 (100)
Patient Toilet Visibly Clean		2 (29)	3 (43)	4 (57)	5 (71)	9 (75)	8 (67)	1 (8)	2 (17)

*Repeated assessments by ward over time

^ Neonatal ICU, † Kangaroo Mother Care, § Post-natal Care

Swab Results

Percent of **Swab Samples** with Target Bacteria^ by Hospital and Ward*



^ Target Bacteria = Positive for *E. coli, S. aureus* or other coliforms (non-*E. coli* coliforms)

*Wards: NICU = Neonatal Intensive Care Unit, KMC= Kangaroo Mother Care, PNC = Post-natal Care

Key Findings

- Hand hygiene stations for clinicians were available 0-86% of the time in Felege Hiwot and 17-75% in Debere Tabor
- Hand hygiene stations for patients and caregivers were available 0-14% of the time in Felege Hiwot and 0% in Debere Tabor

Key Findings

- For Felege Hiwot, fecal contamination (*E. coli*) was detected in 7% of surface swabs, 10% of handrinses, and 0% of drinking water
- For Debere Tabor, fecal contamination (*E. coli*) was detected in 23% of surface swabs, 21% of handrinses, and 16% of drinking water

Key Findings

- The risk of sepsis is 1.5 times greater in Debere Tabor than in Felege Hiwot
- Neonatal mortality is 9.8 times greater in Felege Hiwot than in Debere Tabor
- Infant mortality by day 7 is 1.6 times greater than the 28-day mortality in the Amhara region

Key Findings About Sepsis

- Prevalence of sepsis in newborns was 19.9%
- LBW infants had a 2.4 times greater risk of sepsis and 59.6 times greater mortality than NBW infants
- 89% antimicrobial resistance among sepsis cases
  - 45% are resistant to ampicillin and/or gentamicin

Next Steps

1. Ensure hospital infection prevention protocols follow national and international guidelines
2. Strengthen hospital systems to follow infection prevention guidelines
3. Identify potential interventions
4. Implement and evaluate interventions to reduce neonatal sepsis

Appendix B. Handout for Communication of Synergy Study Results

Synergy Study

Emory Ethiopia, Amhara Public Health Institute, Emory University

What is the Synergy Study?

The Synergy Study took place in two hospitals in Amhara, Ethiopia. One is a referral hospital (Felege Hiwot), and the other is a general hospital (Debere Tabor). The goal of the study was to determine how many newborns born in each hospital develop sepsis, and to assess the water, sanitation, and hygiene (WASH) conditions in the hospitals that may contribute to sepsis development. Data was collected from October 2018 – June 2019.

Methods

Newborns were recruited at birth and followed for the first 28 days of life. Mothers were interviewed and follow-up visits/phone calls were used to determine neonatal health. Blood samples were drawn and tested from newborns with probable sepsis. Environmental conditions of each hospital were assessed through structured observation at baseline and every 2-4 weeks in the neonatal intensive care unit (NICU), kangaroo mother care (KMC), delivery, and post-natal care (PNC) wards of each hospital. Handrinse samples, swabs of surfaces, and water samples were collected and analyzed for bacterial contamination.

The research team collected data through:

- infants enrolled (n=605)
- neonatal blood samples (n=187)
- environmental surface swabs (n=229)
- handrinse samples (n=108)
- drinking water samples (n=58)
- water samples from medical devices (n=47)
- observations of WASH conditions (n=21)

Neonatal Sepsis Results (Preliminary)

Newborn Outcomes by Birthweight (BW) and Facility at 7 days post-discharge

Outcomes	Total	NBW+	LBW+	Felege Hiwot	Debere Tabor
Neonatal Sepsis Incidence* (culture +)	196.99	134.62	327.68	155.96	235.96
Early Neonatal Mortality Ratio^	48.86	2.51	149.70	76.92	7.84
% Neonatal Sepsis Positive (1st samples)	19.9%	13.5%	32.8%	15.6%	23.6%
% AMR (Any AMR/sepsis positive)	89%	49%	68%	94%	80%
%AMR to 1st line empiric therapy	45%	41%	48%	57%	36%

+Low birth weight: <2500g
+Normal birth weight
* Incidence: Outcome / 1,000 infants
^Ratio: Outcome / 1,000 infants

AMR: Antimicrobial resistance
1st line empiric therapy: ampicillin and/or gentamicin

Pathogen Frequency in Neonatal Blood Samples

	Overall (%. Pos)	Felege Hiwot (%. Pos)	Debere Tabor (%. Pos)
Staphylococcus aureus	29	19	38
Klebsiella pneumonia	27	40	16

Results Summary

Neonatal Sepsis and Mortality

- Risk of sepsis in newborns is 19.9%
- LBW infants have a 2.4 times greater risk of sepsis and 59.6 times greater mortality than NBW
- The risk of sepsis is 1.5 times greater in Debere Tabor (DT) than in Felege Hiwot (FH)
- Neonatal mortality is 9.8 times greater in FH than in DT
- Infant mortality by day 7 is 1.6 times greater than the region

Environmental Contamination

- For FH, fecal contamination (*E. coli*) was detected in 7% of surface swabs, 10% of handrinses, and 0% of drinking water
- For DT, fecal contamination (*E. coli*) was detected in 23% of surface swabs, 21% of handrinses, and 16% of drinking water

Environmental Conditions

- Hand hygiene stations for clinicians were available 0-86% of the time in FH and 17-75% in DT
- Hand hygiene stations for patients and caregivers were available 0-14% of the time in FH and 0% in DT

Environmental Conditions Results (Preliminary)

Routine Facility Assessments by Hospital and Ward

	Felege Hiwot (n=7)				Debere Tabor (n=12)			
	NICU	KMC	Delivery	PNC	NICU	KMC	Delivery	PNC
	%	%	%	%	%	%	%	%
Water								
Functional Piped Water	100	86	100	43	100	100	42	67
Treated Water Available	0	0	0	0	100	100	92	92
Treated Ward Water Stored	0	0	0	0	100	100	75	92
Hand Hygiene								
Water and Soap Available for Clinicians/Staff	86	14	29	0	58	75	25	17
Water and Soap Available for Patients/Caregivers	14	0	14	0	0	0	0	0
Hand Hygiene Promotion Materials Visible	43	0	29	0	100	100	92	100
Infection Prevention and Control								
Gloves Available	100	57	100	86	92	100	100	100
Disinfectant Available	86	43	100	71	100	100	92	92
Clean Delivery Surface	-	-	71	-	-	-	42	-
Control Access Point for Ward Entry Enforced	71	-	-	-	100	-	-	-
Environmental Cleanliness								
Safely Segregated Waste	43	29	71	29	25	17	0	0
Ward Visibly Clean	86	100	100	100	83	92	17	8
Staff Toilet Visibly Clean	100	71	86	100	83	75	92	92
Patient Toilet Visibly Clean	29	43	57	71	75	67	8	17

Environmental and Hand Contamination Results (Preliminary)

Frequency of Bacterial Contamination by Hospital and Ward

	Felege Hiwot				Debere Tabor			
	E. coli	*S. aureus*	Other coliforms‡	Total Contaminated	*E. coli*	*S. aureus*	Other coliforms‡	Total Contaminated
	% Pos.	% Pos.	% Pos.	% Pos.	% Pos.	% Pos.	% Pos.	% Pos.
Neonatal ICU								
Swab	4	6	12	16	22	17	52	58
Handrinse	15	10	30	40	24	10	31	41
Water from Medical Device	0	0	5	5	0	0	30	30
Drinking Water	0	-	-	0	7	-	-	14
Kangaroo Mother Care								
Swab	4	6	12	16	45	25	75	85
Handrinse	10	10	40	50	30	50	70	80
Drinking Water	0	-	-	0	20	-	-	20
Delivery								
Swab	12	0	12	33	5	5	0	10
Handrinse	0	33	11	41	11	0	11	11
Drinking Water	0	-	-	0	13	-	-	13
Post-natal Care								
Swab	6	6	6	13	20	5	30	45
Handrinse	10	60	0	70	10	10	0	20
Drinking Water	0	-	-	0	40	-	-	40

‡Coliforms other than *E. coli*, including *Klebsiella pneumoniae*

What are the next steps?

1. Ensure hospital infection prevention protocols follow national and international guidelines
2. Strengthen hospital systems to follow infection prevention guidelines
3. Identify potential interventions
4. Implement and evaluate interventions to reduce neonatal sepsis

Appendix C. Participant Feedback Form for Communication Meetings

Synergy Study Feedback Form

We would like to collect some information from you about today's session. The information you provide below will be used to inform potential interventions at Felege Hiwot and Debere Tabor aimed at reducing neonatal sepsis and mortality. The information will also be used to improve future communication methods and materials by the Synergy Study Team. You are not required to answer these questions. Your responses will not be shared with anyone outside of the Synergy Study Team, except as aggregated results. We appreciate your time and feedback.

Demographic Information:

Name:	Occupation:	Position (including the ward you work in):
Organization:	For how many years have you worked at this organization?	

Synergy Study Results:

Which part of the study results surprised you the most?
What concerns do you have with the study results?
What would you like to know more information about?

Strategies to Reduce Neonatal Sepsis and Mortality:

If you had to choose one aspect of the hospital to change to prevent neonatal sepsis, what would it be and why?
What types of changes/interventions do you think would be most beneficial to reduce neonatal sepsis?
Which hospital policies do you think are adequate to prevent neonatal sepsis? Why?
Which hospital policies should be changed to prevent neonatal sepsis? Why?
How can each aspect of the hospital infrastructure listed below be modified to better prevent neonatal sepsis? Hand Hygiene (sink and soap access)

Hand Hygiene (practices) Toilet Facilities Waste Management Practices Environmental Cleaning Practices Water Sanitation Personal Protective Equipment (ex. gloves) Other
How can hand hygiene and infection prevention training for staff be improved?
How can hand hygiene and infection prevention information be shared with families?

What else would you like to share with us?

Communication Methods:

What did you like about today's presentation?
What would you change about today's presentation?
Please summarize what you learned from this session and what did not make sense to you.
What do you still have questions about?

Synergy Study Participant Feedback Form Data

Things that surprised them

- 12/15 Antimicrobial resistance rates
- 6/15 Neonatal sepsis prevalence, and corresponding mortality
- Hand hygiene:
  - Availability of water and soap for patients and caregivers
  - Poor personal hygiene practice
  - Hand hygiene promotion
- Environmental contamination:
  - DT water contamination and infrastructure

Their Recommendations

- Improve practice of IPC policies (5/15)
  - Increase awareness of staff about drug resistance and health outcomes
  - Train staff on IPC policies
  - Clinician commitment
  - Monitoring and evaluation of practice (including strict follow-up)
  - Change attitude and practice of hand hygiene
  - Improve hand hygiene
  - Improve environmental cleanliness
  - Appropriate use of PPE
- Improve hospital infrastructure
  - Hospitals should fulfill all required safety facilities
  - Improve soap and water availability at every working site
  - Improve waste disposal techniques
  - Better water treatment
  - Have all cleaning and PPE supplies
  - Strengthen WASH facilities
  - Improve NICU functionality
  - Mobilize an HSTQ or QI team
- Improve treatment for newborns
  - Change antibiotic prescriptions
  - Develop appropriate care for newborns
  - Identify risk of sepsis in newborns
  - Culture-based treatment
  - Standard treatment protocols (specifically at DT)
- Results Dissemination
  - Share findings with all healthcare facility staff
  - Give recommendations to health officials
  - Share with primary health institutions
  - Further discussion of drug resistance with staff
  - Mentoring and support from primary hospitals for the NICU
- Considerations for our team:
  - Differences due to COVID-19 prevention
  - Program-specific monitoring and evaluation
  - Continue this research and work with staff to intervene

Policies

<u>Adequate:</u>

- IPC policies (5/15)
- Health education and staff training
- Nursing care
- Supply
- CASH program

<u>Inadequate:</u>

- IPC policies should be updated (3/15)
- Practice of IPC/adherence to policies
- Organization culture to promote better practices
- Staff training (IPC policies and PPE)
- Treatment guidelines (including antibiotic use/resistance policies)
- Clinician commitment
- Access to ICU
- Apply CASH audit findings
- Report IPC trends to health care workers

Infrastructure

- Waste management
  - Clear information about waste separation
  - Modernize waste management practices
- Hand hygiene
  - Promote hand hygiene practices
  - Increase water and soap accessibility
  - Have accessible hand hygiene stations
- Changes for patient rooms/wards
  - Uncluttered NICU
  - Adequate ventilated rooms
  - Make NICU mini operating room
  - Adequate space needed
- Changes for personnel:
  - Create awareness about drug resistance
  - Provide full PPE necessary for use (gloves)
- More and improved toilet facilities
- No changes needed (with recommendation to focus on practice)

Staff Training

- Information to provide:
  - Updated IPC strategies and protocols
  - On-site training
  - Practical training
  - Fomite transmission education
  - Safety training
  - Synergy Study results
- Timing:
  - All new staff
  - Update old staff on new guidelines
- Monitoring and evaluation of practice
- Supportive supervision and follow-up
- Goal: improve staff attitude and awareness

Sharing hand hygiene and IPC with families

At the hospitals: (7/15)

- Educate during admission
- Provide packets/leaflets
- Group discussion among mothers
- Role modeling
- Supervision
- Integrate with hospital guidelines

In the community:

- Health extension program
- Radio and television ads
- Special events

Partners to work with:

- CHD Health Department
- Primary care health institutions
- Health extension program
- WASH projects in the region