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Appropriate Infection Control Practices in Refugee Camps and Post-conflict Settings

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Abstract Cover Page

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Abstract

Appropriate Infection Control Practices in Refugee Camps and Post-conflict Settings

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Edna Kwamboka Moturi

Background
HAIs are a global public health problem, affecting developed and developing countries alike. In the US alone, over 1.4 million people are affected each year. More than 40% of hospitalized patients in developing countries in Asia, Latin America and Sub Saharan Africa, are estimated to be at risk of contracting HAIs. However, administrators of healthcare facilities located in resource-limited settings are faced with the challenge of inadequate resources, with which to implement the recommended infection control guidelines.

Objectives
Study objectives were: to review literature and determine the burden of HAIs in resource-limited settings and refugee camps; search literature bases for guidelines related to infection control; and then draw on personal working experience, to identify realistic infection control recommendations that are financially feasible, adaptable, practical and usable, for application in these settings.

Methods
A literature review was conducted, with inclusion criteria of English studies, unrestricted by time, applicable to resource-limited settings, and not specific to disease, or hospital procedure areas. Search terms included: urinary tract infections, wound infections, surgical site infections, nosocomial, hospital associated, refugee camps, and guidelines. Electronic databases Pub Med, MEDLINE and Google scholar, as well as international agencies' websites, were searched.

Results
145 articles were retrieved. 27 articles had epidemiology data on HAIs in resource-limited settings; these were utilized in the review. 14 guidelines were found to be practical to resource-limited settings. Overall pooled HAIs prevalence was 12.2/100 patients. Most HAIs were found to be associated with improper use of medical devices. SSI's were the most studied, and common infections (12.74/100 procedures). Gram negative bacilli were the most common bacteria isolated.

Conclusion
There is limited available data on HAI epidemiology in developing countries, with no data present for refugee camps and post-conflict settings. There are existing guidelines that can be utilized in refugee camps and post-conflict settings. However, the question of their being used, and their effects is unknown. Practical, administrative, environmental, personal protections, and surveillance infection control measures, need to be implemented, so as to reduce HAI transmission in healthcare facilities.

Emory University CDC – IERHB

APPROPRIATE INFECTION CONTROL IN REFUGEE CAMPS AND POST-CONFLICT SETTINGS

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ACRONYMS

CDC	Centers for Disease Control and Prevention
HAI	Healthcare-associated infection
HCW	healthcare worker
HEPA	High Efficiency Particulate Air (filter)
HIV	human immunodeficiency virus
ICT	infection control team
ICU	intensive care unit
INICC	International Nosocomial Infection Control Consortium
JHPIEGO	John Hopkins Program for International Education in Gynecology and Obstetrics
MDR-TB	multi-drug resistant tuberculosis
MRSA	methicillin resistant *staphylococcus aureus*
OPD	outpatient department
OSHA	United States' Occupational Safety and Health Administration
PPE	Personal Protective Equipment
SSI	surgical-site infection
UNICEF	United Nations Children's Fund
UTI	urinary-tract infection
WHO	World Health Organization

I. INTRODUCTION

A. HEALTHCARE FACILITIES IN RESOURCE-LIMITED SETTINGS

Inadequate resources is the main challenge for governments and administrators of healthcare facilities in resource-limited settings [1]. These settings often lack adequate resources with which to implement health programs according to universally set precautions and guidelines. In most developing countries, the healthcare budget accounts for a small proportion, generally less than 5%, of the gross national product, with other sectors like education and security, receiving top priority [2]. As a result, healthcare facilities in these countries are grossly understaffed and neglected, with most countries experiencing shortages of qualified healthcare workers (HCWs) and lack adequate medical supplies and equipment [2].

Basic infection control measures are often non-existent, compromising the overall healthcare services provided to patients in these countries. Consequently, healthcare-associated infections (HAIs) are commonplace and threaten the lives of patients who are undergoing treatment in healthcare facilities situated in these countries. However, there is a general lack of awareness and prioritization of the seriousness of HAIs, with governments and administrators not investing in infection control programs. Even in countries with a high healthcare budget, the percentage committed to prevention of HAIs is more often than not, inadequate with other immediately emerging infectious diseases taking precedence [3]. In addition, clinicians working in these settings give more focus and priority to these infections and other program needs, neglecting infection control measures. Critical factors leading to increased transmission of HAIs in these settings are scarcity of healthcare workforce (i.e., understaffing), overcrowding, lack of essential equipment and supplies (e.g., soap, clean water, gloves, sterilizers, instruments), re-use of disposable supplies without safe disinfection, lack of knowledge, training and proficiency regarding infection control among staff, overuse of antibiotics, poor hand hygiene practices, lack of aseptic techniques for invasive procedures, improper disposal of waste, lack of surveillance systems, and inadequate microbiology laboratories, among others [3]. Moreover, lack of surveillance systems with which to establish the exact scope of the burden posed by HAIs in resource-limited settings leads to inadequate funding of infection control programs by governments and administrators. There is a deficiency of high quality data reported by these settings to provide information on the epidemiology of HAIs. A combination of the above factors, and lack of infection control practices, have drastically decreased the capacity of the health systems to counter the increased demand for health care brought about by HAIs [2]. As a result, most hospitals' response to disease outbreaks, if at all any, is habitually reactive, instead of preventive [3]. This leads to increasing, avertable levels of morbidity and mortality, even though in most cases, this is undetected and unreported [4]. However, infection control is not a 'resource issue' but rather one caused by lack of awareness and poor management [5]. Even in settings where resources are scarce, successful techniques and systems used elsewhere, can be imitated with specific modifications to suit the local situation [5], e.g., the Republic of Palau, which despite being a small, resource-limited country, has managed to establish a well organized public health system with the use of community ownership, effective behavioral modification techniques, internal training and improvement of infrastructure [6].

B. MY PROFESSIONAL EXPERIENCE IN HEALTHCARE FACILITIES IN RESOURCE-LIMITED SETTINGS

After completion of my 5-year medical studies at the University of Nairobi, I was posted to Kisii District Hospital, Nyanza Province, Kenya as a medical intern and then a medical officer in charge of the hospital's surgical department. Kenya has a high burden of communicable diseases aggravated by dire poverty levels, low water and sanitation coverage, and a health system too weak to respond adequately [7]. The country has a HIV prevalence rate of 7.4%, with women (8.5%) having a higher rate than men (5.5%) [7]. Tuberculosis (TB) control has been a challenge with reports showing an increase in the number of patients with multi-drug resistant TB (MDR-TB). The current TB prevalence is 319 per 100,000 people. The leading causes of morbidity in the country are malaria (30%) and respiratory illness (25%) [7].

Most developing countries conventionally allocate more funding to urban hospitals, which have connections to universities, such as where I received my original training [3]. As a result, urban hospitals have access to specialized medical technology and specialists, while poorly funded rural facilities, like Kisii District Hospital, make do with rudimentary infrastructure and basic cadres of healthcare workers. Kisii District Hospital is a referral center for smaller sub-district hospitals in the area. The hospital is located in a high population density setting, in spite of the region relying on agriculture and most residents in the district being small scale subsistence farmers.

Following my time in Kisii, I proceeded to the Kakuma refugee camp, Turkana District, North Eastern Province, Kenya; as a medical officer in the 120-bed United Nations High Commissioner for Refugees (UNHCR)/International Rescue Committee (IRC) refugee camp hospital. Kakuma refugee camp is a well established camp, which was originally set up in 1992 to serve Sudanese refugees. The camp has since enlarged, and currently serves over 80,000 multi-national refugees from Somalia, Sudan, Ethiopia, Burundi, the Democratic Republic of Congo, Eritrea, Uganda and Rwanda. The hospital also serves over 10,000 nomadic pastoralists from the local Turkana community. The camp is located in a semi-arid desert area, which has numerous problems, such as high temperatures, regular sandstorms, poisonous snakes, spiders and scorpions, widespread malaria, and common cholera outbreaks. The locations of these hospital facilities are illustrated in Figure 1.

I will further describe these two different healthcare settings that I personally experienced: a government district hospital in a resource-limited country and a refugee camp hospital. My aim is to discuss the infection control challenges encountered during the provision of health care in these two settings, and the strategies placed to prevent spread of disease in the facilities. It is important to compare how issues relating to infection control are addressed at a district hospital in resource-limited settings versus at a refugee camp hospital. Healthcare delivery and infection control challenges in these two facilities, will be described according to: i) patient care departments including in-patient, out-patient, laboratory and operating rooms; ii) operational services, i.e., water, sanitation, pest control, waste management , food, general supplies; and iii) HCWs safety.

C. PATIENT CARE UNITS

(i) IN-PATIENT WARD FACILITIES

Kisii District Hospital in-patient wards were distributed in several buildings within the hospital grounds. Each ward provided a specific type of care for each gender, i.e., medical, surgical, psychiatric, pediatric, and obstetrics/gynecology. Each ward had adjourning rooms which served as procedure rooms; however, it was not uncommon for hospitalized patients who required medical procedures to be treated at their bedside. The ward rooms had large windows on opposite sides of the rooms and wide entrance and exit doors. There was no mechanical ventilation, but all windows were open during the day ensuring adequate sunlight and natural ventilation in the wards. There was a small single isolation ward, located in a secluded part of the hospital grounds. Being a rural hospital, the hospital grounds were extensive and buildings were spread out. Inside the wards, the patient beds were arranged in two rows, one on each side of the main corridor. Because of the high demand for beds, the distance between each bed was small and the wards were very congested. It was not uncommon for two patients to share a single bed, with their caretakers (relatives) sleeping on the floor. Patients with suspected infectious diseases, slept on the beds at the furthermost corner of the ward. This was the attempt to isolate them from other patients and reduce transmission of bacteria between patients. Mosquito nets were provided, although most were in various states of disrepair. The wards were cleaned twice a day and patient caretakers assisted with this endeavor. Hand washing stations were present in all wards and procedure rooms. A nursing staff oversaw that soap was availed at most times. The mattresses and pillows were covered with plastic coverings; this was convenient for cleaning purposes.

The hospital had a nursery for pre-terms and newborns. There were five working incubators, with more than one infant sharing one at any one time. Infection control was maintained by restricting people's access to the ward; only mothers and particular HCWs were permitted entrance. They also had to take off their lab coats and shoes; specific 'nursery footwear' was provided to them. Everyone had to wash their hands with soap and water, and put on gloves, prior to touching the infants. Nurses working in the nursery often received supplemental trainings on infection prevention.

The TB ward in Kisii district hospital was located in a separated part of the hospital grounds, away from the masses. In contrast to the other hospital wards, the TB ward was spacious and patients did not share beds. It had large, open windows to provide ventilation. Patients were encouraged to stay outside; it was not uncommon for the nursing staff to direct them to be outside, especially in the afternoon. Patients received health education on TB/HIV prevention whilst receiving treatment. Staff working in this unit received frequent trainings on TB management and how to administer their services without acquiring infection. They were also provided with surgical masks, gloves, gum boots and lab coats for their personal protection. In place of gowns, reusable plastic drapes were used. These were cleaned after use.

The hospital experienced frequent shortages of medical supplies; in these cases, patients and their relatives would be required to purchase gloves, syringes and drugs, before undergoing treatment. Other methods of cost-cutting included re-using syringes whilst administering intravenous (IV) medications. This was commonplace since most patients insisted on IV drugs; they believed it worked better than oral drugs.

The UNHCR/IRC camp hospital's in-patient facilities consisted of six large rooms: female and male general wards, pediatric, TB, maternity, and stabilization center, where malnourished children were admitted. A large refurbished tent served as the cholera treatment center. With the exception of the pediatric and female general wards, there were no procedure rooms, and patients' wounds were tended to at their bedsides. Despite being located in a hot, arid area, there were no air-conditioning units in any of the wards. However, all buildings had open windows, and the doors were for the most part were kept open allowing adequate ventilation and sunlight. Sand storms were common, leaving a coat of sand and dust on all surfaces. Hospital beds were arranged differently depending on the shape of the room, though the distance between beds was small. The camp hospital had a 120 bed capacity; however due to frequent damages, the number of available beds was significantly lower than 120. This bed scarcity was worse during peak malaria seasons or disease outbreaks, when the admission rates would escalate forcing multiple patients to share beds. It was not uncommon to find patients sleeping on floor mats or on the ground outside. This was detrimental during the rainy season, when patients would fall victim to scorpion, spider and snake bites. Each bed had a mosquito net; however, the temperatures in the camp prevented most patients from using them, since it would be too uncomfortable. Non-governmental organization (NGO) workers who resided in the camp had a similar viewpoint. However, they had access to fans in their rooms hosted in the NGO compound. With no isolation facility in the camp hospital, patients with infectious diseases slept in the same ward as other patients, although their beds were placed apart from the others. Hospital wards were kept clean, with the help of the cleaning staff who were hired from the refugee community and paid a monthly incentive for their work. Hand washing stations were present in all wards, and liquid soap was availed. The camp hospital received its water supply from a sunken borehole, which was managed by an NGO working in the camp. However, the water distribution system was prone to frequent disruption, because of theft apparently by members of the nomadic local community of PVC pipes that transverse the camp. As a result, lack of running water was a common problem in the camp hospital.

There was no nursery in the camp hospital, because there were no extra rooms in the maternity ward. Preterm babies shared beds with their mothers. Those with critical conditions were placed in the acute section of the maternity ward for close monitoring. Because of lack of adequate nursing staff, the role of feeding and bathing the preterm babies, was done by the mothers with supervision from the only one hospital midwife. Staff and relatives were expected to wash their hands and wear gloves before handling the babies.

The TB ward was located in a separate part of the camp hospital grounds. The room had large, open windows. Beds were placed at a reasonable distance from each other, to prevent transmission of droplet nuclei. Patients were encouraged to maintain good personal hygiene and practice cough etiquette. The clinical staff working in this area would often conduct their consultations outside, rather than in the ward. Only critically ill patients were reviewed in the room. The TB outpatient clinic and HIV testing center were located in the adjacent building. The outdoor area between these two structures provided a venue for health education and food distribution to people living with HIV. So as to provide them with privacy, this area was surrounded by a fence. Posters with information on TB /HIV were displayed on the walls of the buildings, to educate people on TB infection, transmission and prevention.

Both Kisii District Hospital and the UNHCR/IRC hospital had security guards manning the gates leading to the in-patient facilities. The guards' role was to provide crowd control, and regulate access to the in-patient wards by patient relatives and visitors. At Kisii District Hospital, patients were identified by means of exclusive hospital gowns, whilst in Kakuma the patients had special admission books. However, this process was not infallible, and as a result there was frequent movement of staff and relatives between wards, increasing the risk of transmission of infections.

(ii) OUT-PATIENT CLINIC FACILITIES

Typical out-patient services, available in Kisii District and Kakuma hospitals comprised medical, surgical, pediatrics, obstetrics and gynecology clinics. These clinics, except the TB clinic, were carried out in the same rooms, although each was held on separate days of the week. In addition, TB/HIV, immunization and antenatal services (ANC) were provided. In order to attend these clinics, patients must have scheduled an appointment well in advance. Because there were few clinicians available in both hospitals, a maximum number of patients were selected for any given day. As a result, the clinic had a long waiting list of people in need of consultation but not obtaining appointments. It was not uncommon to find several people with no appointment, showing up in the hopes of getting a consultation. Furthermore, patients had to wait for long periods of time, since the clinicians had to first conduct in-patient ward rounds, prior to running the out-patient clinics. Consequently, the out-patient setting was often overcrowded, and on occasion disorderly. The HCWs working in this unit were overworked and this frequently compromised the quality of care they gave the patients. The consultation time was short and brief; in addition, antibiotics and analgesics were frequently overprescribed.

(iii) LABORATORY AND IMAGING SERVICES

Being a referral facility, Kisii District Hospital offered laboratory and imaging services. Routine basic tests were available and the hospital provided systems of transporting samples, to Nairobi city for specialized laboratory work. However, these services were costly and most patients could not afford to pay for them. Only X-ray services were available, though patients had to make an appointment, unless in emergency situations; this could often take several weeks. Therefore, the patients who could afford would be forced to go to private hospitals in order to access CT and MRI imaging. Those who could not afford these tests would request discharge from the hospital so as to go home and look for ways to secure the funds. This led to delay in diagnosis with fatal consequences. As a result, clinicians often made clinical diagnosis without laboratory and radiological results. The laboratory was located in the out-patient area, and only specific staffs were allowed to enter the room. Patients and their relatives had no access to the laboratory. Samples were dropped off, and results collected through a small window. Laboratory staff wore lab coats and gloves whilst working. They also underwent annual medical examinations which included X-rays to check for TB. They also benefitted from frequent targeted trainings.

At the UNHCR/IRC camp hospital, laboratory services were present. The refugees received free health care and specific medical tests. Routine laboratory tests were done, with the exception of TB or routine culture; these necessitated transportation to Nairobi. Access to the laboratory was restricted to patients and their families. The laboratory was the only air conditioned area in the hospital. Patients lined up for sample collection in the outer room, which also served as the point for collection of results. There was also a small inner room where staff carried out administrative work. Laboratory staff wore laboratory coats, surgical masks and gloves whilst working. They too received frequent trainings and on job supervision. They were subjected to annual medical examinations to rule out infections. Patients needing chest x-rays, were referred to Kakuma mission hospital. For more advanced imaging, they would be referred to Nairobi.

(iv) OPERATING THEATERS

The UNHCR/IRC Kakuma refugee camp hospital did not provide major operating services or cesarean sections. Patients in need of surgeries were referred to the neighboring Kakuma Mission Hospital, located 15-20 minutes away, in the nearby Kakuma town. They were transported by an IRC ambulance, which was available 24 hours a day.

In contrast, Kisii District Hospital, being a referral hospital, had two surgical theaters. The main theatre was used for general surgical cases, while the other was for obstetrics and gynecology cases. The separate obstetric theatre was constructed because of the large numbers of caesarian sections conducted in the facility; an average of 800 per month. However, despite having two theaters, only one was operational on most days, since there was a shortage of anesthetics. This frequently led to a pile up of pre-operative surgical patients in the wards, since emergency cases received first priority. The delay in treatment contributed to poor surgical outcomes, with several developing post-operative sepsis, with some proving fatal.

The Kisii surgical theatres were located in rooms that had air conditioning facilities. The tiled floors were cleaned as soon as each operation was finished. Surgeons washed their hands with antiseptic soap and water before performing surgical procedures. If there was no running water in the taps, a student would assist the surgeon, by pouring out water from containers. Surgeons always wore two pairs of sterile gloves when performing surgeries. HCWs working in the surgical theatres were well versed in infection control and safe surgical guidelines. The head nurse was responsible for ensuring that infection control practices were adhered to by everyone. Medical interns and students who were beginning their surgical rotations, would be given a brief practical training on how to perform their duties in the theatre whilst maintaining good hygiene standards.

The sluice room was located next to the operating room. Dirty linen were washed with warm soapy water and hung out to dry in the sun. Reusable surgical instruments were also manually cleaned, then soaked with disinfectant. Subsequently, both the linen and instruments would be sterilized in a steam autoclave. Biohazard bags were used to collect body parts, blood and body tissue waste. These were then burnt in the incinerator.

D. OPERATIONAL SERVICES

(i) SANITATION FACILITIES

Kisii District Hospital had several toilets in the wards and out-patient building for patient use. There were also latrines located near the hospital entrance, accessible to relatives, visitors and patients who were awaiting admission. These were separate from staff toilets, which were locked up; one needed a key to access them. Hand washing facilities were in close proximity to the toilets. Subordinate personnel were responsible for cleaning the toilets and latrines daily.

Latrines were also present in the UNHCR/IRC Kakuma hospital, though at a smaller number. All the in-patients utilized four latrines; two for males and two for females. One latrine was located in the out-patient area for use by patients and family members. The HCWs made use of one latrine, which was locked at all times, to restrict access. Patients' bedpans would be emptied into the latrines by their family members. Hand washing facilities were present close to the latrines. Refugees hired as incentive cleaning staff were responsible for the daily cleaning of the latrines.

(ii) WATER FACILITIES

Kisii District Hospital received its piped water supply from the municipal town. It also had large water tanks, which met the hospitals needs during water shortages. Patients used this water for drinking, showering and cleaning purposes. Hand washing was done with the use of antiseptic soap and water at the many hand washing stations located all over the hospital. Patients, family members and HCWs were encouraged to wash their hands before and after patient care, and after the use of toilets. The hospital did not provide alcohol-based sanitizers. The water drainage system was also provided by the town.

At the UNHCR/IRC Kakuma hospital, water was supplied from a sunken borehole. However, there were no water reservoirs, which led to frequent water shortages. The water was chlorinated at the borehole site, by a local NGO working in the camp. Hand washing was done with liquid soap and water. Liquid soap was preferred as it was less prone to theft than bar soap. There was also no alcohol-based hand sanitizers used in the facility. Cleaning water was discarded by pouring onto the ground. In cases of overflow or leakage, the runoff would be directed to outside of the hospital compound.

(iii) PEST CONTROL

Malaria is endemic in Kenya. Both Kisii and Kakuma, have high prevalence rates of malaria. Outbreaks have been reported during the rainy seasons. Because of this, pest control to reduce the mosquito population is very important. At Kisii District Hospital, mosquito nets were provided to patients for their use throughout their stay at the hospital. Open water swamps were drained, and grass on the hospital grounds was kept short to prevent mosquito breeding. The wards were sprayed regularly with insecticide. HCWs would shut the windows and doors of the wards at night, to help reduce the numbers of mosquitoes inside the ward.

At the UNHCR/IRC camp hospital, mosquito nets were given to patients. Open water reservoirs in the hospital grounds were drained, and internal residual spraying carried out twice every year. Thick bushes and hedges were trimmed often to prevent mosquito breeding. In both these hospitals, malaria diagnosis and treatment was a priority. Staff watched out for signs of rodents; if spotted, rat kill baits were set up all over the hospital.

(iv) WASTE MANAGEMENT

Kisii District Hospital had a well set up waste management system. Biological waste (body parts, body fluids and contaminated medical equipment), was collected twice a day from each ward, placed in biohazard bags and taken to the hospital incinerator for burning. Non-medical garbage was collected in different containers and also burnt at the incinerator. Food waste was collected in different bags and deposited in a composting pit. Sharps were disposed in narrow mouthed, non-collapsible containers placed in every room in the hospital. When full, the containers were disposed of by incineration then buried. The incinerator, compost pit and sterilizing unit were located at a distance, away from the kitchen and main hospital. Bodies were treated with dignity. They would be transported from the wards, and taken to the mortuary, using a specialized route inaccessible to patients and visitors. This was done as soon as a death occurred.

At the UNHCR/IRC camp hospital, similar measures were taken to ensure proper waste management. Sharps were collected in standard containers. When these containers were out of stock, jerry cans would be modified for this use. Body fluids, body parts and contaminated medical equipment were collected in plastic bags and burnt in the incinerator. The hospital did not have mortuary facilities. Bodies were placed in a designated room to await pick up and burial by the family members. As such, burials took place within hours or a day of death.

Both these hospital however, faced problems in the sterilization departments. There was lack of proper quality control in disinfection and sterilization. In order to cope with the heavy workload, nurses from Kisii District Hospital would delegate these duties to students from the local medical training college; while at Kakuma; untrained refugees were allocated these duties.

(v) FOOD FACILITIES

At Kisii District Hospital, food was stored in a permanent store located near the kitchen. There were adequate conditions for food storage with refrigeration facilities available. Food was centrally prepared by kitchen staff, with supervision from the matron who ensured that hygiene was maintained. Meals were served on patients' individual plates (relatives brought plates and spoons). The staff working in the kitchen had to provide medical proof of good health, before being allowed to work in the kitchen.

At UNHCR/IRC camp hospital, food supplies were stored in a store located within the NGO compound to avoid theft. Food was thus transported to the hospital when necessary. There were no refrigeration facilities hence cooked food was not stored overnight. The kitchen was located in a building inaccessible to the public. Kitchen staff were hired from the refugee population and had to undergo routine medical examination before working the kitchen.

(vi) HEALTHCARE WORKERS (HCWs)

Both hospitals lacked sufficient numbers of HCWs to provide treatment to the patients. Kisii District Hospital had consultants and qualified nursing staff. However because of inadequate salaries, HCWs' morale was low. As such, the bulk of the health care delivery in the hospital was provided by medical interns and nursing students, with low supervision from the trained personnel. It was not uncommon for consultants to report to work for a few hours each week, because they were working in their private clinics and hospitals to supplement their income. The hospital permitted one family member to stay with the patient in the ward. Patients' family members played important roles in providing nursing care to the patients. They were responsible for feeding and bathing the patient, making and changing their beds and disposing of his/her waste. They also brought meals from home to supplement the bland tasting hospital food.

Kakuma hospital faced a shortage in all cadres of HCWs. There was a high turnover of doctors and nurses, with holidays and leaves contributing to frequent understaffing. Vacations were taken after staying at the camp for 90 days; though in most cases one would be forced to stay for a longer duration because of staffing issues. As such, HCWs experienced fatigue and stress related symptoms. This made them prone to fatigue related accidents. In order to manage the patient load, HCWs relied on refugees recruited and given short training courses to enable them to provide health care. They were paid a small monthly incentive for their labor. However, most trained refugees were unqualified and lacked knowledge on infection control practices. They were responsible for the running of the hospital during the night, because NGO workers were not permitted to be present in the camp, due to security concerns.

In both these hospitals, rapid HIV tests and post-exposure prophylaxis (PEP, were readily available to HCWs who were at risk of occupational exposure to infection. Vaccination and counseling services were also provided to the hospital staff. Table 5 gives a summary of the infection control weaknesses present in these two healthcare facilities.

II. BACKGROUND

To set the stage for my study, I will begin by first defining key terms used in the thesis, and providing a brief background of: i) refugees and refugee camps; ii) resource-limited settings; iii) HAIs mode of transmission, overall burden and consequences; iv) role of healthcare workers in HAI transmission; and v) global burden of antimicrobial resistance.

(i) REFUGEES AND REFUGEE CAMPS

According to the 2011 UNHCR Global Trends report, by the end of 2010, an estimated 437 million people had been forcibly displaced because of ongoing wars and persecution worldwide [8]. This is a 1.5% increase from the figures reported at the end of 2009, with numbers of refugees who have been voluntarily repatriated during the course of the year, balancing the new refugees resulting from ongoing conflict. These people encompass UNHCR's population of concern; they include various groups, including refugees, asylum-seekers, internally displaced persons (IDPs), stateless persons and returnees (returned refugees and IDPs). In order to These people encompass UNHCR’s population of concern; they include various groups, including refugees, asylum-seekers, internally displaced persons (IDPs), stateless persons and returnees (returned refugees and IDPs). In order to recognize these individuals as persons of concern, UNHCR and legal authorities must first determine whether their situations meet the criteria for each group’s definition. Once their refugee status is determined, they can then be registered and protected.

The term ‘refugee’ has undergone several changes in definition over the years. Following the end of the Second World War, the International Refugee Organization (IRO) was created by the United Nations to take care of the more than 20 million refugees that had been displaced in Europe by the two World Wars [9]. During this period, resettlement became a viable solution to the refugee problem; this led to several, mainly European, refugees being resettled into third countries, predominantly the United States. UNHCR replaced the IRO in 1951; it was charged with ensuring that all countries accept refugees, guarantee them protection and prevent them from forced repatriation and persecution [9]. They also were responsible to find a lasting solution to the refugee problem. Currently, UNHCR deems refugees according to the 1951 Status of Refugees Convention, the 1967 Protocol, and the 1969 Convention governing the specific aspects of refugee problems in Africa as individuals granted complementary forms of protection or having “temporary protection” [8]. Therefore, according to UNHCR, a refugee “is a person who owing to a well-found fear of being persecuted for reasons of race, religion, nationality or political opinion, is outside the country of his/her nationality and is unable or, owing to such fear or for reasons other than personal convenience.

Most refugees arise from complex humanitarian emergencies (CHEs). These are man-made disasters that are caused by war, armed conflict or civil strife, and are characterized by severe public health consequences due to the resultant massive population displacement, food scarcity and collapse of governments [10]. Absent or unstable governments and ongoing conflict limits access to basic services for the affected people and bring about significant human and economic losses.

In recent years, there has been an increase in the number of reported natural disasters globally, e.g., flooding in Pakistan (2010), earthquakes in Haiti and Japan and 2011 respectively. However, Japan was able to cope with the disaster. The former two disasters contributed to the increased numbers of displaced people by disrupting the society's functioning and causing widespread human, material or environmental losses exceeding the ability of the affected society to cope. Natural disasters occurring in developing countries may give rise to disease outbreaks, leading to high rates of morbidity and mortality, by compounding pre-existing poor health situations [10]. Disasters typically have four phases, namely: pre-emergency, emergency, post-emergency and reconstructive phase [11]. However, these phases do not often follow a vertical order, but rather a cycle as seen in countries that have undergone one type of a disaster after another, with no break for reconstruction and development, e.g., Niger [12].

The severity of emergencies is measured by the crude mortality rate (CMR) of affected populations. This is the number of deaths per 10,000 people per day. In Sub-Saharan Africa, which has high pre-emergency rates, the doubling of the CMR from the baseline, during emergencies is regarded as being high, i.e., 2 deaths per 10,000 per day [13]. Monitoring the

CMR helps to differentiate the separate phases of disasters, as well as the level of the emergency, e.g., in the Rwandan camps, the CMR increased by 40-69 times the baseline indicating a critical emergency situation [14].

Immediately following CHEs, refugees flee their homes and often settle in refugee camps managed by humanitarian agencies [9]. In the past, most refugees were residing in established refugee camps but currently, more than half are residing in urban areas [15]. Refugee camps are meant to be safe places and provide refugees with a secure environment, away from war, civil strife, personal attacks, human right violations, fear and persecution [16]. While living in a camp, refugees are expected to have access to at least a minimum of food, shelter, health care and other basic needs. Although organized refugee camps do provide refugees with safety, protection and humanitarian aid, living conditions within the camp are often times deplorable, with most refugee camps located in hardship areas [16]. The residents rely completely on assistance from agencies for their survival. Currently, most CHEs occur in developing countries. UNHCR reports that despite common beliefs, the majority of refugees seek refuge in neighboring countries. Consequently, the UNHCR 2010 Global trends report states that four-fifths (80%), of the world's refugees are being hosted by developing countries, with one out of two residing in an urban area [8]. This has placed an enormous burden on developing countries, most of which are some of the poorest countries in the world, i.e., among the 25 countries with the highest number of refugees, all are developing countries, including 15 which are the least developed countries in the world [8]. These additional refugees overstretch the economic capacities of these host countries, causing hostility with the indigenous persons because of competition for the limited water, wood and farming ground [9].

Refugee camps are intended to be temporary shelters established with the hope that once the conflict in the refugees' home country has resolved, they will be able to return home in dignity and security. However, this is seldom the case [9]. UNHCR recommends three durable solutions to the refugee situation: i) voluntary repatriation to the home country, ii) permanent integration in the country of asylum, or iii) resettlement in a third country [8]. Of the above, voluntary repatriation is the preferred, durable solution to the world's refugees, but this is often hindered by continual conflict, fear, persecution and lack of basic services in the refugees' home countries. By the end of 2010, more than 7.2 million refugees were living in a total of 29 protracted situations globally, for a period longer than 5 years [8]. This is the highest number recorded since 2001, with many residing in refugee camps that have been in existence for many years, e.g., Kakuma refugee camp where I worked. These chronic camps necessitate long-term planning for services to be provided to refugees long after the emergency period, with the humanitarian agencies relying on international financial support to maintain those services in the protracted camps. However, aid given to chronic camps has been decreasing, with donors focusing more on the latest emergencies [17]. This reduces the amount of resources available to provide basic health-care services to the refugees, especially those in protracted situations.

At the end of 2010, UNHCR reported that most refugee and internally displaced camps are located in developing countries of Africa and Asia [18]. These countries often have unstable governments and ongoing insecurity and skirmishes restricting access, lack of medical supplies and medicines to the vulnerable refugees and internally displaced people in the camps [19]. Refugee camps are often located in remote sometimes desolate parts of the countries, and are more often than not usually overpopulated, which can make them ideal to epidemics of highly communicable diseases. Moreover, living conditions in refugee camps are dire, with lack of adequate food, water, sanitation; vaccination and health services magnifying the problems. In addition, refugees often come from countries with poor health and nutrition profiles; these factors may lead to further weakening of their immune systems, rendering them vulnerable and at increased risk of contracting infections [19]. For that reason, refugee camps present settings conducive for transmission of infectious diseases and HAIs. The main causes of morbidity and mortality in complex emergencies are communicable diseases- malaria, acute respiratory diseases (ARI), measles and diarrheal illnesses, or in combination with malnutrition [19]. Factors promoting communicable disease transmission interact synergistically in complex emergencies causing high rates of morbidity and mortality. These include mass population movement, resettlement in temporary locations, overcrowding, economic and environmental degradation, impoverishment, scarcity of safe water, poor sanitation, waste management, absence of shelter, poor nutritional status as a result of food shortage and limited access to health care services [20]. Because there is often lack of adequate infection control practices, outbreaks are common, e.g., the measles outbreak that occurred in 1992 in Tuareg refugee camp, Mauritania. 40% of the childhood deaths were attributed to the outbreak [20]. In the Rwandan refugee camps in Goma, the crude mortality rates were very high (20-35 per 10,000 per day), mainly due to communicable diseases like dysentery, cholera and shigella [21]. The added problem of collapsed public health infrastructure and absence of health services hampering prevention and infection control and surveillance programs. This leads to a rise in vector-borne diseases like malaria, trypanosomiasis and yellow fever and in vaccine preventable diseases, like measles and pertussis [19]. The control of HIV/AIDS, tuberculosis and other chronic non-infectious diseases is similarly disrupted. In countries affected by complex humanitarian emergencies, there could occur, a resurgence of old or previously controlled disease or emergence of drug resistance caused by improper use of drugs and absence of regulatory control, e.g., multi-drug resistance tuberculosis [19]. Countries affected by conflict, could also provide potential zones of new disease emergence because of delays in detection and characterization of new pathogens and their widespread transmission before control measures can be implemented e.g., monkey pox in the Democratic Republic of Congo [19]. Often this is because unstable governments do not have strong health ministry's that can set up surveillance systems, vaccination programs and health systems that can enable early detection and treatment of infectious cases [22]. These frequent delays in detection, response and containment of epidemics in conflict affected countries also represent a threat to surrounding countries and to the world as well because of the threat of pandemics [19]. Infection control in refugee camps and emergencies should be enhanced because failure to do so might lead to the amplification of epidemic prone diseases like cholera, viral hemorrhagic fevers, like Ebola, HIV/AIDS and hepatitis A. Diarrheal illnesses are often a major cause of morbidity and mortality in complex emergencies, and account for more than 40% of deaths in the emergency phase with more than 80% of the diarrheal deaths occurring in children under the age of 2 years [19]. Causative factors include inadequate quality and quantity of clean water, substandard and insufficient sanitation facilities, overcrowding, poor hygiene practices and scarcity of soap. In refugee camps, they lead to outbreaks mainly due to common sources of infection. Agencies offering health care to refugees need to put infection control programs, or practices so as to prevent transmission of HAIs.

(ii) RESOURCE-LIMITED SETTINGS

Countries with limited economies have been described with a variety of names. The most common is the World Bank classification, which is based on countries' gross national income (GNI) per capita [23]. Using their GNI per capita, countries are categorized as being low income, middle income (further sub-divided into lower middle and upper middle), or high income. Low income and middle-income countries are sometimes referred to as developing countries. This classification of countries based on their economies is convenient for the World Bank's lending purposes, but does not necessarily reflect the country's development level [23]. Another option of classifying countries is the Human Development Index (HDI), which takes into account both the per capita income and educational attainment and life expectancy [23]. The United Nations describes the least developed countries as having the lowest indicators of socioeconomic development and the lowest HDI rating [23]. Developing countries and resource-limited countries are thought to be synonymous, with the two words used interchangeably in several literatures to refer to underdeveloped countries, having income levels per head of population low by the standards of North America, Western Europe and Australia [24]. These countries have vast diversities in the cultural, education, political, religion, natural resources and social conditions. However, they also have several common features and problems, which include: i) low living standards, ii) low productivity levels, iii) high population growth and dependency burdens, iv) dependency on agriculture as primary industry, and vi) dependency on international aid [25]. These countries characteristically have high levels of poverty, ongoing conflict (war/ ethnic clashes), and lack of political and social stability. The majority of these countries are located in Sub-Saharan Africa [25].

(iii) HEALTHCARE-ASSOCIATED INFECTIONS (HAIs)

HAIs refer to the infections associated with healthcare delivery in any setting: hospital, long-term care facilities, ambulatory settings, and home care [26]. Friedman, et al defines HAIs as " infections occurring in patients at least 48 hours, from the time of admission; if the patient was hospitalized for two or more days in the 90 days before infection; or if he or she resided in a nursing home or long-term facility"[26].

The Centers for Disease Control and Prevention (CDC) defines HAIs as: "localized or systemic conditions resulting from adverse reactions to the presence of an infectious agent or toxin with no evidence that the infection was present or incubating at the time of admission to the health care setting. The affected person is thus infected by a HAI as a result of being exposed to health care delivery" [26].

HAIs are a global public health problem affecting developed and developing countries alike. In the US alone, over 1.4 million people are estimated to be affected each year [27]. They are considered to be the most common infections threatening admitted patients' health worldwide [1], with the rate of HAIs viewed as an indicator of the quality of medical care services and level of patient wellbeing provided by health facilities [5]. However, it is often difficult to accurately determine the source of the pathogens in HAIs since patients are exposed to several pathogens while receiving medical treatment or during their overall duration of stay in the health facilities [28]. Furthermore, over 70% of HAIs are reported to be caused by pathogens resistant to one or more antibiotics [4]. Additionally, medical advances in invasive diagnostic and treatment procedures have contributed to the sharp increase in the risks of acquiring HAIs [3].

The HAI burden in resource-limited settings is largely unknown because of challenges that exist in collecting reliable diagnostic information. However, it is estimated that more than 40% of hospitalized patients in developing countries of Asia, Latin America, and Sub-Saharan Africa having HAIs [5]. Patients in the developing world have a 25% greater risk of contracting HAIs when compared with patients in the developed world [5]. The World Health Organization (WHO) Patient Safety Challenge Team estimates the HAI rate in developing countries to be double the HAI rate in the United States [29]. These settings have inadequate resources resulting in non-existent basic infection control measures [3]. Inappropriate, uncontrolled antibiotic use has further aggravated transmission of HAIs [30].

HAIs pose a great health burden to patients, their families, HCWs and healthcare systems. They may lead to disease outbreaks, which in the case of epidemic prone pathogens, e.g., norovirus, cholera, can affect massive numbers of people. The huge number of affected people will lead to an increased demand for medical services and supplies in areas with already strained resources. This overloads an already compromised healthcare delivery and often may result in excess morbidity and death. They may result in disabling conditions leading to emotional stress, decreased quality of life, and in some cases death [31]. Substantially, HAIs increase the financial burden by causing prolonged length of stay in hospitals; costly healthcare services: i) diagnostic tests and ii) treatment with expensive second and third line drugs used to treat multidrug-resistant bacteria; and indirect economic cost associated with lost days of work [32]. Majority of HAIs are associated with improper use of medical devices, e.g., urinary catheters, intravenous catheters, mechanical ventilators, and surgical procedures.

The most common HAIs are: i) urinary-tract infection (UTI) associated with indwelling catheters, ii) surgical-site infections (SSI), iii) bloodstream infections associated with intravascular devices, iv) lower respiratory tract infections, which are often associated with ventilators, and v) gastrointestinal infections [33]. These infections occur mostly in patients with lowered immunity due to age, underlying disease, or chemotherapy. According to the WHO, the highest infection rates take place in acute surgical and orthopedic wards [33].

(iv) MODE OF TRANSMISSION OF HEALTHCARE-ASSOCIATED INFECTIONS

So as to develop effective methods of preventing HAIs within healthcare facilities, it is important to understand the conditions necessary for their transmission. Infection transmission, and in particular HAIs, typically require three key elements: i) a source of the infectious pathogen, ii) a vulnerable host, and iii) a mode of transmission [34].

Human beings are the primary sources of infectious pathogens within the healthcare setting. These comprise hospitalized patients, HCWs, and patients' family members who circulate within the healthcare facility; they all function as the main transmitters, receptors, reservoirs and sources of micro-organisms. While patients may have overt clinical signs and symptoms of disease, the rest though asymptomatic, could be in the incubation period of diseases or chronic carriers of infectious pathogens [35]. Contaminated inanimate objects and surfaces in the patient's immediate environment also could be a source of infection, especially when poor hygiene is practiced [36].

Various individual characteristics influence the host response following exposure to pathogens: i) some may be predisposed to developing disease; ii) others may fight off the disease; iii) while others may become asymptomatic carriers with no apparent disease [35]. Extremes of age, underlying diseases, e.g., HIV, radiotherapy, invasive medical procedures, wound or mucosal membrane injury, surgery, indwelling catheters (urinary/ intravenous), and immunosuppressive conditions may reduce the immunity of the hosts, rendering them more susceptible to acquiring HAIs [34].

There are various routes through which infectious pathogens are transmitted within healthcare settings. There are five main established ways of transmitting micro-organisms: i) contact, ii) droplet, iii) airborne, iv) common vehicle, and v) vector [35]. Additionally, the same pathogen could have multiple modes of transmission, making control more difficult. These modes of transmissions are described in Figure 2. The main route of HAI transmission within a healthcare setting is contact, since most patient care activities involve direct or indirect contact between HCWs and patients [35]. The vector mode of transmission is very important in resource-limited settings and refugee camps, given that these insects are prevalence of these areas. Thus, refugee camps have a huge burden of vector borne diseases, e.g., malaria and dengue.

Infection control measures targeted on breaking off the mode of infectious disease transmission, have been shown to be more effective than the control of the human host or infectious agent [35].

(v)HEALTHCARE WORKERS AND HEALTHCARE-ASSOCIATED INFECTIONS

HCWs working in resource-limited settings and refugee camps encounter a number of infectious diseases and wound-related conditions. They may have to manage these conditions, with inadequate laboratory support and protective equipment. Occupational exposure puts them at high risk of contracting HAIs and transmits these infections to their patients and their own families [37]. The risk is especially high for those dealing with body fluids like blood, amniotic fluid, sputum and tissue on a daily basis; those who clean and process instruments, and clean up after procedures; those who work in operating theatres and procedure rooms; and those who dispose medical waste. Duration of employment plays a significant role with a higher risk present in those who have been employed for a longer period of time, since it increases their exposure to the pathogens [38].

The problem of occupational risk to healthcare workers is often overlooked in resource-limited countries, with resultant gaps in protection measures against infection of the workers. Most information regarding occupational risk has been derived from studies conducted on TB transmission in health facilities. TB is a very contagious disease and the risk of transmission to healthcare workers exposed to TB patients because of their occupation has been known for many years [39]. This risk increases in facilities that work in endemic area resulting in high numbers of TB patients, a situation common in resource-limited settings. The emergence of MDR-TB and consequent re-emergence of TB has resulted in an increase in TB incidence rates in the population and has increased the risk to workers [40]. Resource-limited settings have a huge burden with large numbers of TB patients, hence their focus has largely been on case diagnosis and treatment in a bid to reduce mortality, thus leaving limited resources for infection control measures to protect their healthcare workers from contracting the disease [41]. Studies attempting to explain the occupational risk of TB transmission to HCWs may be limited by their inability to distinguish occupational from non-occupational exposure; especially, if the workers had pre-existing infection prior to starting work. There also may be population characteristics that affect the transmission rates, e.g., some hospitals may have older HCWs who are at higher risk of infection with TB than younger HCWs thus limiting their external validity [41]. Rajnish, et al reported the attributable risk for TB disease in HCWs as ranging from 25 to 5,361 per 100,000 per year [42]. The level of risk of contracting TB HAIs varied depending on the type of work done in the hospital facilities. The study authors found high risk levels of acquiring TB in HCWs who worked in the in-patient TB wards, laboratory staff, in-patient medical wards and emergency facilities, with radiologists, patient attendants, nurses and clinical officers having high risk [42].

Given their prolonged and frequent contact with patients, nurses have been identified as having the highest rates of HAIs [41]. Physicians working in general medical wards, pathologists and laboratory staff, also have high infection rates [41]. Individual characteristics among HCWs may predispose them to infections; for example, HIV-infection or advanced age. A systematic review looking at TB infections among HCWs, reported that 8 of the 17 HCWs with MDR-TB, were HIV positive [39].

Inadequate infection control practices also have been reported to significantly increase the risk of HCWs contracting TB [40]. HCWs have been reported to have poor compliance to hand washing; even in developed countries adherence to hand washing by HCWs is estimated to be less than 50% [43]. In addition to being at risk for acquiring HAIs, HCWs have been implicated in transmission of hepatitis B and C, with studies reporting transmission rates, ranging from 0.2% to 13% [44]. Vaccination against hepatitis B has resulted in decreased rates of transmission. However, the cost implication involved in vaccinating all HCWs, has limited the use of this strategy in resource-limited settings. Priority should be given to HCWs who are working in high risk wards like TB wards, because of the increased risk that they face. Though it is not possible to completely eliminate the risk of acquiring HAIs by HCWs, effective infection control measures could lower the risk to a level similar to that of the general population [26].

(vi) GLOBAL ANTIMICROBIAL RESISTANCE

Approximately 70% of HAIs are reportedly caused by micro-organisms that are resistant to one or more antibiotics. Moreover, developing countries have an excessive infectious disease burden with gastrointestinal, respiratory and sexually transmitted infections (STDs) accounting for significant causes of morbidity and mortality [30]. Worse, with growing antimicrobial resistance, the management of these infectious diseases has been compromised, with terrible consequences. Due to lack of resources, developing countries are not able to make available the newer, more effective antimicrobials, which are better able to manage these infections [30]. Treatment of resistant infections leads to prolonged duration of stay in hospitals, further increasing the cost of health care. This rapid resistance has been attributed to antimicrobial misuse and lack of effective infection control measures.

Diarrheal diseases are a leading cause of illness in developing countries, with factors contributing to their transmission, unsafe water, inadequate sanitation and poor hygiene, being common in these countries [45]. Gastrointestinal infections affect people of all ages, and are responsible for most healthcare visits; as such, these diseases are prone to antimicrobial misuse and over prescription [30]. As a result, many bacterial pathogens, responsible for causing diarrheal disease, are developing rapid, growing resistance to antimicrobials. *Salmonella typhi* and *Shigella flexineri* have in recent years developed resistant to ampicillin, chloramphenicol and co-trimoxazole; all inexpensive drugs that are freely available in developing countries [30]. This resistance also is linked with the increase in severity of the disease and resulting mortality [46]. In India, 50%-70% of *S. typhi* are resistant to the first line treatment of cholamphenical, leaving third-generation cephalosporin's as alternative treatment in endemic areas [30]. *S. flexineri* has been found to be responsible for the majority of bacillary dysentery cases in developing countries, including epidemics of dysentery, especially in African countries [14].

Epidemic dysentery has fatal consequences, especially in children. Resistance to cheap, first line drugs, have made the expensive fluoroquinolones, the only alternative treatment [30]. These drugs are unaffordable by most people, hence compromising health outcomes. Antimicrobials help shorten the duration of illness and break the transmission of cholera. However, *Vibrio cholerae* is increasingly showing resistance to tetracycline and other antimicrobials [30]. During the 1996 cholera epidemic in Guinea-Bissau, surveillance reports showed a multi-drug resistance strain of *V. cholerae,* which was resistant to common antibiotics; the resistance was associated with an increase in number of confirmed cholera cases, as well as an increase in the case fatality rate from 1% to 5.3% after the emergence of the resistant strain [47].

Acute respiratory infections account for nearly one fifth of mortality in young children worldwide [48]. Of these, *Streptococcus pneumoniae* is responsible for up to 70% and also causes other common childhood illnesses, e.g., otitis media, bacteremia, and bacterial meningitis [49]. More than 50% of children in developing countries are colonized with *S. pneumoniae* before they are 6 months of age; while in developed countries, colonization occurs much later in life [30]. Resistance has been documented in South Africa of bacterial meningitis causing *S. pneumoniae* strains that were only inhibited by excessively high doses of penicillin [50]. In a prospective survey carried out to determine prevalence of *S. pneumoniae* in children under 5 years of age in Botswana and to determine the antibiotic resistance patterns of these organisms to commonly used antimicrobials, the authors found resistance to at least one antimicrobial in approximately half of the isolates [50]. With resistance to co-trimoxazole and penicillin, the authors recommended the use of third generation cephalosporin drugs, to be the first-line drugs to treat the childhood infections in that area [50]. TB control programs, especially in developing countries, are facing a challenge of increasing cases of MDR-TB. MDR-TB cases are those with *Mycobacterium tuberculosis* strains that are resistant to at least isoniazid and rifampin, and often to other drugs [51]. MDR-TB treatment is devastating to patients and their families, as well as being a huge drain to health systems because of the expensive drugs and long course of treatment. With the background of an HIV epidemic, MDR-TB may result in outbreaks of HAIs by being transmitted to HIV-infected patients in facilities; this makes it the worst opportunistic infection associated with HIV [51]. During the MDR-TB outbreak that took place in Mûniz Hospital, Buenos Aires, the lack of proper infection control policies in the hospital were to blame for the failure of the hospital to control the outbreak [52]. MDR-TB was spread from the TB ward to affect patients throughout the hospital. Also the outbreak reportedly spread to other hospitals via patients seeking care [52]. This makes MDR-TB a serious problem for public health programs worldwide.

Despite a decrease in prevalence, gonorrhea remains one of the most common STIs in developing countries [30]. Caused by *Neisseria gonorrhoeae*, it is associated with development of pelvic inflammatory disease, infertility in women, and an increased risk of HIV transmission [30]. In recent years, *N. gonorrhoeae* strains, which produce penicillinase have been increasing worldwide. These bacteria are challenging STI control programs in developing countries of Africa and Asia, by showing resistance to multiple drugs, including penicillin and tetracycline [53]. This has resulted in expensive third generation cephalosporins and fluoroquinolones, having to be seen as first line drugs in treatment of gonorrhea [54]. To determine the prevalence of penicillinase-producing *N. gonorrhoeae (PPNG)* in the Gambia, Adegbola, et al tested 103 strains of *N. gonorrhoeae* isolated from a peri-urban STI clinic. They found seventy-nine (77%) of the isolates to be PPNG, and all of the isolates were resistant to tetracycline [53].

Thus, antibiotic resistance is a huge public health problem which is being propagated by failures of disease control programs in developing countries. Factors that have contributed to this increase include: i) inappropriate and uncontrolled use of antibiotics, ii) availability of antibiotics over the counter without prescription, iii) suspect quality and potency of antibiotics due to unregulated import, registration and distribution, and iv) lack of antibiotic policies [3].

II. STUDY OBJECTIVES

Based on my past working experience and given my new understanding of infection control challenges facing healthcare facilities in refugee camps, I chose to conduct a study aimed at identifying appropriate infection control practices in refugee camps and post-conflict settings.

The study objectives were to: i) review existing literature and estimate the HAI burden in refugee camps and post-conflict settings, drawing on the HAI burden in resource-limited settings, ii) find existing guidelines related to infection control practices in resource-limited settings, then drawing on my professional experience working in resource-limited settings and refugee camps, iii) identify realistic infection control recommendations that are financially feasible, adaptable, practical and usable for application in these settings.

IV. METHODS

A literature review was conducted with an inclusion criterion of English studies, unrestricted by time, applicable to resource-limited settings, and not specific to a disease or hospital procedure area. Search terms were used alone or in combination. They included: urinary-tract infections, wound infections, surgical-site infections, nosocomial, hospital associated, antimicrobial resistance, resource-limited, refugee camps, post-conflict settings, developing countries and guidelines. Studies conducted in intensive care units also were excluded. The electronic databases Pub Med, MEDLINE, Cochrane library, and Google scholar as well as websites of known international agencies working in infection control, i.e., United Nation agencies (WHO, UNICEF), Engender Health, CDC, John Hopkins Program for International Education in Gynecology and Obstetrics (JHPIEGO), and International Nosocomial Infection Control Consortium (INICC), were searched for relevant publications.

Over 2000 articles were initially found. As per exclusion criteria, those articles with information on specific infection control practices restricted to antenatal care, abortion, maternity, child care and community settings were excluded. Those describing measures applicable only in the developed world were also excluded. In addition, articles with interventions for specific diseases, e.g., malaria, TB and HIV were excluded. In total, 145 articles were selected and found to be relevant to the objective of the literature review. Further review found 64 articles ineligible because they were too specific in their objectives; 11 were not written in English; 14 did not have original data; and for 13 abstracts' full text could not be retrieved. This left a total of 43 articles. Of these, 9 were found to contain data from countries that were discovered to have high GDP per capita, hence not meeting the set criteria of resource-limited settings [55]. Seven articles did not have denominator data and were also eliminated. This left a final total number of 27 articles, which were included in the final analysis. A summary of the articles selection process is illustrated in Figure 3. Extracted data included: authors; year of publication; country or region where the study was done; setting and type of study; sample size and type of patient population (children, adult, gender); type of infection (overall healthcare-associated infection, at least the four most frequent infections: i) urinary-tract, ii) surgical-site including post-caesarean section wound infection, iii) non-central venous catheter (non-CVC) bloodstream, and iv) non-ventilator associated infections; definitions used for diagnosis (reported infection prevalence or point incidence data); and related denominators and numerators. The point incidence reported, refers to the number of either new infections or new patients acquiring an infection per 100 patients, who are followed up for a defined time period. For SSI, this is usually 30 days after surgery, whereas for other infections it refers to the duration of hospital stay [56].

The studies were stratified into six regions according to the WHO classification, i.e., Africa, Europe (using only eastern European countries because of HDI classification), Southeast Asia, Mediterranean, Western Pacific, and the Americas [2]. Overall HAIs included studies of infections that were hospital-wide among newborns, infants and adults. Numerators and denominators were determined for the time interval provided by each article whether a prevalence study, or prospective incidence study. Using the numerators and denominators, prevalence rates were determined for each of the specific HAIs. From these, pooled prevalence rates were computed using SAS version 9.2. At a significance level of 0.05, a one sample t-test was performed to calculate the 95% confidence intervals for each pooled prevalence rate. Box-plots were constructed using the five number summaries. Figure 4 and 5 illustrate box-plots for the pooled prevalence of overall HAI infections, and SSIs respectively.

V. RESULTS

A. HEALTHCARE-ASSOCIATED ARTICLES

(i) RESULTS

The resulting region-specific stratification of resulting articles is demonstrated in Table 1. The low number of articles from Southeast Asia (11.1 %) and Eastern Europe (11.1 %) is mainly because most of the studies retrieved from these regions, had been conducted in intensive care units (ICUs), hence ineligible for inclusion in this review. As illustrated in Table 2, 40.7% of all the articles were prevalence studies, while 59.3% were prospective cohort studies in which patients were followed up for different lengths of time.

Overall HAI infections were reported in 15 studies, and the pooled point incidence ranged was 12.2 per 100 patients (95% CI: 9.1-15.8). A box plot indicating the range of pooled prevalence of overall HAI infection is shown in Figure 4. Of the 27 articles reviewed, 16 focused on SSIs. The pooled point incidence of SSI was 12.74 per 100 patients (95% CI: 6.29-19.20) undergoing surgical procedures. A box plot demonstrating the range of pooled prevalence of SSI is shown in Figure 5. Microbiological data were available from 16 studies. Most identified pathogens were related to SSI. Gram negative bacilli were the most common bacteria isolated in the studies. The most common single pathogens were *Staphococcus aureus, S. epidermidis* and *Klebsiella pneumonia.* Six articles reported high rates of methicillin resistant *S. aureus.* Only six included data on antimicrobial resistance patterns. The pooled prevalence of UTIs was found to be 3.91 per 100 patients (95% CI: 1.5-6.31) from the five articles reporting incidence rates for UTIs. Tables 3 A, B and C, demonstrate the results of the overall HAI, UTI and SSI reported in the study.

B. Infection Control Guidelines Practical To Refugee Camps And Post-Conflict Settings

14 guidelines were found to be practical for use in refugee camps and post-conflict settings, of which six were utilized in developing the following recommendations. Most were developed due to international reaction to the emergence of life-threatening pandemics, e.g., severe acute respiratory syndrome (SARS), which highlighted the fact that healthcare facilities could amplify outbreaks by increasing the number of cases [57]. These infections drew attention to the need for effective infection control programs in all healthcare settings, so as to prevent transmission to patients and HCWs.

In 2004, the World Health Organization (WHO) launched the World Alliance for Patient Safety in response to a World Health Assembly Resolution passed in 2002, which urged the WHO Member States to pay the closest possible attention to the problem of patient safety [29].

The Global Patient Safety Challenge ‘Clean Care is Safer Care’ (CCiSC), was a core program of the World Alliance aimed at drawing attention to patient safety. CCiSC was the first campaign launched in 2005-2006 and it led to the development of the WHO Guidelines on Hand Hygiene in Health Care whose objectives were to prevent HAIs through improved hand hygiene, blood safety, injection and immunization safety, safer clinical practices, safe water, sanitation and health care waste management. The core message of the campaign was: ‘simple measures save lives’ and focused on preventing HAI by simple interventions, like hand hygiene [29]. These objectives will be met through efforts to; i) increase global awareness on HAIs as a major public health burden, ii) improve countries’ commitment to infection control, and iii) identify and test sensible recommendations to implement infection control measures worldwide [25]. As a follow up to this alliance, several developing countries reported improvements, with developing infection control guidelines and training programs, and setting up surveillance systems [33]. Infection control practices within healthcare facilities aim to: i) protect the patient, ii) protect HCWs, visitors and others within the hospital environment, from acquiring HAIs, and iii) achieve protection in a cost-effective manner [58].

The second challenge, Safe Surgery Saves Lives, commenced in 2007 and was formally launched in 2008. The third challenge launched in 2010, focused on the unprecedented spread of drug resistant pathogens and the implications for patient safety [5]. Most guidelines for infection prevention and control include appropriate hand hygiene as a key recommendation. The commonest methods of hand hygiene used during routine patient care include hand washing with plain or antibacterial soap and hand rubbing with alcohol based or other antiseptic based hand rubs. The CCiSC ‘five moments approach’ to hand hygiene recommends washing hands: before touching a patient, before performing a clean/aseptic procedure, after body fluid exposure/risk, after touching a patient, and after touching a patients surroundings.

The guidelines emphasized the education, training and knowledge of HCWs so as to increase their awareness of HAIs and infection control precautions. Key among this is to increase HCWs compliance to hand hygiene and ensuring their safety by improving compliance in use of personal protective equipment, vaccination, and post-exposure prophylaxis. Environmental management practices include ensuring adequate ventilation, clean water, proper waste management, cleaning, disinfection and sterilization of instruments, and handling dead bodies. Patient placement and infection control issues during transportation were addressed. Six guidelines emphasized measures to ensure appropriate antibiotic use.

The 1985 landmark SENIC study which was initiated by CDC and looked into the efficacy of infection surveillance control programs in preventing infections showed that with intensive infection control and surveillance programs, an overall reduction of 32% in HAI rates could be obtained within a five year period [59]. A more recent review conducted by CDC found a minimum reduction effect of 10% to a maximum of 70% depending on the setting, study design, baseline infection rates and type of infection [59].

Table 4 lists the guidelines found to have feasible infection control practices that can be applied in resource-limited settings and refugee camps.

C. DISCUSSION

In this study, HAIs have been shown to be a significant burden in resource-limited settings and is higher than that seen in developed countries, even without considering ICU surveillance data. They represent a health risk for patients admitted to general medical, pediatric and surgical wards in healthcare facilities located in these settings. However, there is limited data available on HAIs in resource-limited settings, with no existing data for the burden of HAIs in refugee camps and post-conflict settings. Thus, the overall burden in refugee camps and post-conflict setting is estimated or assumed to be a significant one. More studies need to be carried out in these areas so as to quantify this burden.

Disorders that have been in the past associated with industrialized countries have been rising considerably in developing countries, e.g., ischemic heart disease, cerebrovascular disease and cancers. There is also an increase in injury and trauma rates caused by road traffic accidents necessitating lifesaving essential surgeries to be performed [60]. When compared with the average prevalence of HAI in Europe (7.1 per 100 patients), and the US (4.5 per 100 patients) [2], the pooled prevalence of HAIs in resource-limited settings is substantially higher (11.2 per 100 patients). However, this incidence is lower than that reported in previous studies, which included ICU data (15.5 per 100 patients). This could be explained by the fact that HAIs are more likely in ICUs where there is a higher use of medical devices and invasive procedures.

SSIs are the most frequently studied, and the leading cause HAIs in resource-limited setting; with most wound infections occurring after caesarean sections. This review found a SSI pooled point incidence of 12.74 per 100 surgical procedures. This is much higher than the US reported SSI incidence of 2.6 per 100 surgical procedures. Most surgeries are expensive to perform, hence the overall rates of surgeries performed in resource-limited settings, are still significantly lower than those done in developed countries. However, there has been a noted significant increase in the numbers of surgeries performed globally [60]; and increase caesarian delivery rates in developing countries have been shown to cause improvements in the overall emergency obstetric care services [61]. As the caesarian section rates in developing countries increased from 0% to about 10 %, both maternal mortality and stillbirth rates have been reported to decrease sharply [62]. However, there is a reported increase in unnecessary caesarian sections performed in the developing countries, especially in private hospitals. In one study done to estimate the incidence rates of caesarean sections in Latin America, over 850,000 unnecessary caesarean sections were found to be conducted each year in the region [63]. These unnecessary operations present an increased risk of infection to the mothers and newborns. There is generally poor perinatal care in resource-limited settings, with poor antenatal care leading to late presentation of complicated obstetric cases. As a result, caesarean sections are often performed as emergency operations under unsterile settings increasing the risk of infection.

Despite their importance, surgeries have high death and complication rates, which lead to mortality hence surgical safety is an issue of great public importance. The conditions under which surgeries are performed need to enforce proper infection control practices so as to avoid post operative sepsis. Prophylaxis antibiotics are not given before surgeries, to reduce the risk of post operative surgical infection and sepsis [64]. Other complications of maternal surgeries might be anemia, post partum hemorrhage and puerperal psychosis brought about by prolonged hospital stay necessitated by the infections [65]. Antimicrobial resistance in these settings is increasing the rates of mortality as a result of surgical site infections. In addition, few studies reported the presence of antimicrobial resistance in their microbiological isolates. Most articles reviewed, reported that most SSIs were detected after patients had been discharged from hospitals. This stresses the need for surgical patient follow up after discharge. It is important to also educate family members and patients on signs of infection following discharge from hospitals.

Gastrointestinal diseases are important infectious diseases in resource-limited settings, especially in the under 5 age group. They are caused by a wide variety of pathogens including enteric and aquatic bacteria, enteric viruses and enteric protozoa [66]. The HIV epidemic seen in developing countries has also re-introduced opportunistic enteric bacteria, and led to an increase in immune-compromised hosts, who are at risk of acquiring diarrheal illness [45]. Food and water supplied to patients and HCWs, whilst in health facilities, may act as vehicles of HAIs transmission leading to serious outbreaks of fecal-oral disease. This is more so in facilities with poor hygiene and lack of infection control practices. It has been proposed that 70% of diarrheal illness globally could be caused by contaminated food, with 30% resulting from polluted water origin [66]. Epidemic viral diarrhea is caused primarily by the norovirus, previously called Norwalk virus and Norwalk-like virus genus of the calicivirus; these viruses affect people of all age groups, and are primarily transmitted by faecally contaminated food or water [67]. This is because these viruses are endemic in drinking water and are highly resistant to chemical disinfection procedures. Thus, they require stringent public health and infection control measures. Gastrointestinal epidemics, and especially those due to norovirus, are frequently under-declared and more common than those caused by bacteria; the main reason being inadequate diagnostic technology [66].

Cholera caused by toxigenic *V. cholerae*, is a major bacterial cause of diarrheal disease in developing countries. Serogroups O1 and O139 have been associated with cholera epidemics. From 1817 to 1994, seven pandemics of cholera occurred; all these were limited to developing countries of South and Southeast Asia, West and East Africa and South America [67]. It is associated with poor water and sanitation; with infected water being the source of food contamination in most cases [66]. Cholera outbreaks typically lead to huge numbers of infected patients, admitted in hospitals. If proper infection control practices are not instituted, cholera might be transmitted as HAIs. Infected HCWs and personnel, responsible for preparing patients' food may be implicated in the spread of the outbreak within a facility and in the community. Between May and October 2007, there was a cholera outbreak in the Thai-Myanmar border. A 71- year old diabetic female, who had undergone a craniotomy following intracerebral hemorrhage, contracted cholera as a HAI 37 days after admission to a female ward in the hospital. She had receiving a nasogastric tube fed diet four times a day from her caretaker. Investigations revealed the tube diet to be contaminated with the same biotype and serotype, as the one cultured from the caretaker [68]. This shows how infected HCWs and patients' relatives can cause transmission of HAIs in hospital when poor infection control and hygiene practices are present [68].

Hospital-based infection control programs aim at preventing HAIs by interrupting the chain of transmission of infectious diseases [69]. While considerable progress has been made in infection control programs in developed countries, implementing these programs in developing countries and refugee camps is hampered by financial constraints, limited laboratory capacity, poor infrastructure, inadequate environmental hygiene, understaffing, prolonged inappropriate use of invasive medical devises, lack of infection control guidelines use, reuse of equipment (needles, gloves), inadequate staff training in standard infection control practices (i.e., hand hygiene, isolation, aseptic technique, cleaning and disinfection or sterilization of re-used equipment), lack of elimination of point source contamination, and poor quality control and improvement [4]. As a result most health care facilities are grossly understaffed and there is a shortage of qualified health care workers to cater for the populations [63]. As a result, most of these settings have non-existent or improperly implemented infection control programs [3]. In addition, delays in detection and response systems exacerbate the situation contributing to excessively high rates of morbidity and mortality associated with HAI transmission within healthcare facilities, located in these settings [19].

D. STUDY LIMITATIONS

There were limited high quality studies describing the epidemiology of HAIs in resource-limited settings. Most articles used non-standardized case definitions and surveillance methods that could have missed HAI patients. Cross-sectional studies were unable to provide incidence and risk of HAIs. Many of them were conducted in single wards, or in teaching or referral hospitals where there are typically higher rates of HAIs, and hence not representative of the countries or regions. There were no studies that had been carried out in refugee camps or post-conflict settings. Lichtenberger, et al reported the infection control challenges experienced by HCWs responding to the earthquake in Haiti, but no data on HAI prevalence were provided [70].

Many resource-limited countries, especially those situated in Africa, had no published data. Most studies were conducted in Latin America and Europe with the guidance of the INICC, a multi-national research network established to control HAIs in resource-limited countries [24]. There was lack of microbiological data with few articles reporting antimicrobial resistance results. The literature search retrieved studies which had been done in hospitals with ICU facilities. Because the study objective was to find articles practical to refugee settings, which do not have ICU facilities, they were excluded, resulting in limited number of articles reviewed.

There are existing guidelines available with practical infection control practices that are feasible in refugee camps and post-conflict settings. These guidelines need to be utilized in a comprehensive manner, with administration support to ensure their success. However, the question of their being used and their effects in preventing HAIs is unknown. There are no available tools for evaluating the effectiveness of these programs, and use of guidelines in these settings. Therefore, there is a need to develop an evaluation tool for infection control practices in refugee camps and post-conflict settings to assess use of guidelines and reduction of HAIs within health facilities, which is simple and user friendly. This would assure quality healthcare provision to refugees and vulnerable people. The CDC/WHO TB evaluation tool could be used as a reference guide during the development process (see: http://www.cdc.gov/globalhealth/gdder/ierh/ResearchandSurvey/tbtool.htm).

E. GUIDELINE LIMITATIONS

However, some weaknesses were noted in the guidelines. Some guidelines contain measures that are not practical for application in refugee camps and post-conflict settings due to the high cost implication and labor intensive nature of the guidelines, e.g., use of respirators, negative pressure rooms and isolation rooms [35].

A number of guidelines were not comprehensive for use within entire health facilities but rather specific to one focus area, e.g., hand hygiene. Most of these were developed after the SARS epidemic. These targeted guidelines have been shown to have poor outcomes [57]. Follow up reviews conducted in various health facilities, reported low compliance to these targeted guidelines, mainly because of inadequate administrative support and feedback [71]. Guidelines which implemented several interventions in combination with guideline use, education and training, organizational change and surveillance, were reported to have better outcomes [71].

VI. RECOMMENDATIONS

Most strategies for reducing infection control in developing countries take a leaf from the WHO guidelines on preventing TB in poor countries. These guidelines provide practical and affordable measures that improve infection control in hospitals and healthcare facilities.

Following my review of the available practical guidelines and from my personal experience, I propose the following practical four components of infection prevention, which are based on the CDC hierarchy of safety and health controls and the WHO core-components of infection prevention and control programs [72]: i) administrative and training, ii) engineering, iii) personal protective equipment, and iv) surveillance and laboratory. These categories were used to develop infection control recommendations, following the 2009 H1N1 influenza pandemic [73].

A. ADMINISTRATIVE CONTROLS

Administrative controls are often the first level infection control measures and have been proven to be the simplest, easiest, most cost effective and cheapest infection control measures [41]. Single control measures have the ability to cause widespread reduction in HAI transmission. They also include trainings for HCWs on prevention strategies against HAI transmission. Infection control practices are categorized into: i) standard precautions, and ii) additional transmission precaution [35]. Application of these basic practices within healthcare facilities can prevent the transmission of HAIs to patients, their families and HCWs.

Administrative controls are geared towards providing a safe healthcare delivery, by facilitating implementation of infection control practices.

(i) TRAINING AND EDUCATION OF HCWS, PATIENTS AND/ OR FAMILY MEMBERS

Administrators are responsible for ensuring that all HCWs are aware of the dangers they face in their day-to-day jobs. HCWs also should be informed of standard infection control practices, which can protect them and their patients from acquiring HAIs. In order to achieve this, HAIs and infection control must be acknowledged as a priority concern, by the facility administrators. Experience from developed countries, shows that HAIs control programs perform best if the clinical staff owns the responsibility for preventing infection transmission with an infection control team (ICT) providing expert support and acting as facilitators to the administration. Each facility should develop an infection control manual with guidelines, which should be adhered to by all HCWs. The objectives should follow the national infection control guidelines, which should be developed by the Ministry of Health with WHO support. This manual should be routinely updated. An infection control consultant could be requested from WHO and CDC, to spearhead initial staff training. He/she would facilitate training of trainers (TOT), among the HCWs, especially members of the ICT. They would also be called upon to provide refresher trainings and evaluation of infection control programs. The TOTs can then train their colleagues hence ensuring continuity.

Training topics would include: sterilization and disinfection of medical equipment, barrier nursing, donning and removal of gloves, handling sharps, handling infectious material.

This is especially for those working in sensitive areas, e.g., surgical, laboratories, pharmacy and intensive care units. Staff should also receive trainings on aseptic methods of carrying out procedures, especially during invasive medical procedures, e.g., IV fluid insertion, catheterization, blood transfusion, and surgical operations. They also should be trained on how to clinically diagnose HAIs. Even in the absence of laboratory confirmation, a clinical diagnosis of a HAI can be made by an experienced senior clinician [5]. Simple clinical case definitions of common HAIs should be developed and these protocols displayed on walls in every patient care area. For example, a device associated HAI's case definition would be any patient with a device that was used at least 48 hours before the onset of infection. Administrators should provide resources for purchasing materials and equipment, necessary for the implementation of infection control practices. The ICT, which would be composed of senior members from all cadres of HCWs, with assigned infection control duties should be created in each facility [57]. Every department head ought to be a part of this committee. This team would be responsible for assessing infection control practices carried out in their departments and overall facility, ensuring staffs comply with the guidelines, and facilitating staff training, i.e., on the job training, awareness programs. The selected members would receive training on infection control practices and would in turn train their colleagues and assist in evaluating infection practices. The practice of training trainers should be employed so as to increase the numbers of HCWs capable of training their colleagues. The ICT should set clear aims with time specific, measurable goals and specific targets for specific patients and locations, e.g., to reduce incidence of surgical site infections by a defined % in a defined period in the general surgical wards and other wards in the facility.

The team leader must have direct reporting lines with the director of the healthcare facility, so as to have authority to implement his/her duties. In addition to the facility, every patient care department should have written policies detailing infection control practices that should be practiced. The head of the department is responsible for ensuring that staff and patients adhere to the policies. The facility should have clearly written work plans, for planned regular assessment of infection control measures, to ensure that the facility is providing safe care to patients [57]. HCWs should provide patients with health education at every opportunity. The administration should provide information and education (IEC) materials on infection control and ensure that they are hang up and are accessible to everyone accessing the facilities. These should be clear graphics and in a language that can be understood by all for them to be followed. Patients and staff should be educated on cough hygiene practices, e.g., looking away from HCWs and visitors when coughing, coughing into their inner arm

(ii) RAPID DIAGNOSIS AND TREATMENT OF PATIENTS WITH INFECTIOUS DISEASES

The most cost-effective way of disrupting the process of disease transmission is the rapid diagnosis and treatment of infectious disease patients [41]. This is a great challenge facing resource-limited settings and refugee camps, because of lack of adequate diagnostic and laboratory facilities. However, strict observance to the syndromic case definitions for clinical signs and symptoms of suspected infectious diseases would be an effective way of achieving this, e.g., a person with a cough lasting > 3 weeks, with associated fever and weight loss should be investigated for TB; patient exhibiting clinical features indicating suspected HIV infection should be tested for HIV. In facilities experiencing shortages of laboratory staff, administrators should hire a subordinate staff to serve as a 'cough officer,' responsible for collecting samples from the wards, transporting them to the laboratory, and bringing back the results to the ward as soon as they are ready. This approach has been used in a Malawi medical ward, with significant reduction in delays of diagnosis and treatment initiation of infectious smear positive TB cases [74].

Most resource-limited settings and refugee camps have insufficient numbers of health care personnel. Therefore, requiring full time infection control staff is unrealistic. It is thus recommended that all HCWs put more effort on 'high risk' patients who are viewed as being at a higher risk of acquiring HAIs to prevent HAIs transmission [75]. This has been shown as being effective in reducing infection rates. These 'high risk' patients include post-operative patients, TB/HIV patients, malnourished patients and others with reduced immunity.

(iii) INVESTIGATE INFECTIOUS DISEASE PATIENTS AS OUT-PATIENTS

Patients with suspected infectious diseases, are often reasonably healthy, until the later stages of the disease [76]. At the time of seeking healthcare, they usually do not require admission, but rather investigation to confirm or rule out the medical condition. However, because diagnostic facilities in most resource-limited settings are poor, and due to the long duration required for confirmation; suspected patients are often times admitted into facilities. Hospital admission is convenient for the patients, since facilities may be located a long way from their homes, and it may be expensive to travel to and fro for tests. It is also convenient for HCWs, who are able to investigate the patients at a more relaxed pace, instead of being rushed for immediate results. This situation leads to high numbers of unwarranted hospital admissions, thus exposing patients to increased risk of acquiring HAIs. Contaminated environmental surfaces (inanimate surfaces) [36], and close proximity to infectious patients, are proven risk factors of disease transmission. Measures should be instituted to reduce unnecessary admissions, thus reducing congestion in the wards. For that reason, facilities should have clear, written guidelines on admission and discharge criteria. These guidelines should be displayed in the out-patient and in-patient care areas, so as to remind HCWs. Patients who are reasonably healthy and ambulant should be investigated as outpatients, whenever possible. TB patients should be investigated whilst in a specific designated well ventilated room, with proper recording of patients' demographic details, tests done, results and follow up to assist in contact tracing.

Out-patient facilities should not allow crowds of people to wait in congested, poorly ventilated waiting rooms. Patients should await consultations outside, where there is plenty of sunlight and fresh air. Benches and seats should be constructed outside, with a cover from rain and sun for their comfort.

(iv) COHORTING AND PATIENT PLACEMENT

Ideally, infectious patients should be cohorted from other patients, especially those with low immunity, e.g., infants, elderly, and patients with HIV/AIDS or TB. This practice is important given that close contact with an infectious patient, is a known risk factor for infectious disease transmission [77]. Strict isolation is not possible in most resource-limited settings and refugee camps, due to lack of resources to construct extra rooms for cohort purposes. Nevertheless, efforts should be made to separate infectious patients from other admitted patient, within the facility. In the open general medical wards, attempts should be made to ensure adequate spacing between beds. The recommended space is 1-2 meters [57]. Patients suspected to have infectious diseases, should be admitted to beds kept together in the farthest section of the ward. This section should be temporarily or permanently partitioned, in order to limit contact with other patients. Once confirmatory diagnosis has been made, infectious patients ought to be transferred to a different ward. TB patients should be cohorted in a separate TB ward from non-TB patients until three times sputum smear negative. In the absence of permanent structure, these wards could be situated in temporary tents.

Because most facilities in resource-limited settings and refugee camps do not have laboratory capacity with which to provide confirmation of MDR-TB, it often takes a long time to diagnose these cases. For that reason, all smear-positive patients, should not be admitted in the general medical wards, but rather to the cohort ward until they become smear negative [57]. There should be minimal movements of these patients from the room, except for specific medical investigations. The patient should always wear a surgical mask to minimize dispersal of infectious droplet nuclei [57]. Patients with infectious diseases should not be allowed to visit other wards. During the MDR-TB outbreak that took place in Muniz hospital, Buenos Aires, there were no guards to prevent HIV-infected patients from walking into the TB buildings.

Consequently, there occurred an HIV-associated MDR-TB outbreak, because these patients were exposed to MDR-TB cases [52].

(v) FAMILY MEMBERS OF PATIENTS

In most cases, patients are accompanied by family members and relatives, some of whom may stay with the patient in the healthcare facility. They are also important in resource-limited settings and refugee camps, because they often bring home-cooked food for the patients, thus supplementing the hospital food, and providing healthcare to patients. However, patients' family members and visitors may facilitate transmission of HAIs within a facility by crowding around patients' beds and incessantly moving to and from the wards. Therefore, it is important for health facilities to ensure adequate crowd control and restrictions; this is especially important for wards where infectious patients are hospitalized. There ought to be a healthcare facility policy, limiting the number of family members allowed to reside in the facility with the patient, usually one. A gated fence should enclose in-patient and isolation wards, with a guard restricting access and controlling traffic. Patients, their relatives and staff should be provided with forms of identification like admission cards, uniforms, or hospital gowns, if possible, so as to assist the security staff to control human traffic movement in the facilities. This will enable restriction of high risk wards and areas and reduce transmission of infections. Family members should not be allowed to visit other wards. Their movements within the facility should be restricted. In Muniz hospital, the outbreak was also spread by family members, who were allowed to go into other wards in the hospital [52].

In facilities with shortages of nursing staff, patients' family members can be utilized to perform simple nursing duties, freeing the few nurses to carry out infection control duties [78]. A study done by Gentile, et al in Argentina; showed that parental infection control education and recruitment to perform routine low risk procedures was easily implemented. This freed the few nursing staff to focus on greater infection risk practices; as a result, there was a significant decreased risk of HAIs transmission [79]. The authors showed that family members are able to carry out traditional nursing duties, including daily hygiene of the patient, patient room housekeeping, management of food, nursing bottles, and waste disposal, control of visitors and basic isolation practices. They carried out these duties under supervision and in turn the nurses were able to supervise high risk procedures more carefully and adhere to infection control practices and implement Universal Precautions. However, the parents should be provided with gloves and protective equipment, and trained on how to use them properly. This intervention is feasible, effective and practical in resource-limited settings where it is impractical to establish an infection control program because of shortages of personnel and financial resources. It can be implemented in one or more high risk wards and if successful, it could be expanded to the whole facility.

(vi) HEALTHCARE WORKERS' SAFETY

The health of HCWs is important for any successful healthcare system. HCWs are at risk of acquiring HAIs while carrying out their duties. They also can transmit infections to their patients or to their family members at home. Sick HCWs cannot perform their healthcare duties, and often require medical leaves, aggravating the shortage of human resources experienced in resource-limited settings and refugee camps. Therefore, facility administration should institute measures to protect their employees from contracting infectious diseases. If possible, HCWs should work in shifts (maximum 12 hour), so as to reduce the dangers of fatigue-related accidents, which increase the risk of infections.

During employment, new employees should be questioned about their overall health, immunization history and presence of medical conditions that would make them vulnerable to acquiring HAIs, e.g., diabetes [57]. This information should be utilized when designating employees' work stations. HIV-infected HCWs have an increased risk of acquiring TB, and deteriorating to a diseased state [80]. Molecular epidemiology technique studies have shown that in about two-thirds of HIV-infected people, TB infection is due to recent transmission, and not reactivation of latent disease [81]. Therefore, HIV-infected staff should avoid working in wards and areas with TB patients and 'high risk' areas, e.g., laboratories working with *M. tuberculosis* specimens, TB wards, and general medical wards. Isoniazid preventive therapy (IPT) with 300mg once a day for six to twelve months has been suggested as being an effective strategy to prevent TB infection in HIV-infected HCW [41]. However, this strategy has not been successfully implemented since HIV-infected HCWs experience stigma and discrimination in the workplace, and most staffs fear the repercussions of divulging their HIV status [41]. If possible, the administration should provide systems to ensure privacy of HCWs medical records and clear policies on no stigma or discrimination to workers infected with HIV. Staff should undergo periodic testing and retesting for TB, especially those working in high risk areas, like the laboratories. Attempts should be made to provide HCWs with confidential ways of testing for

HIV. The administrators should provide all HCWs with information on clinical signs and symptoms of HIV, and options of requesting transfer from high risk areas, if they suspect that they are infected.

Written policies on post-exposure management for common infectious diseases prevalent in the area should be developed, e.g., HIV, hepatitis B, rabies, TB, SARS, rubella. Protocols should be placed in all work stations so as to be a constant reminder on how to carry out medical procedures and respond to emergencies like needle pricks or contact with contagious materials. These policies should include: i) immediate treatment of these infections in the likelihood of exposure; and ii) information provided to HCWs on how they can protect themselves from acquiring these infections, especially if they are exposed to contagious materials. These are standard and additional transmission infection control practices: i) policies on the management of infectious waste, i.e., sharps, blood, human tissue, secretions; and ii) reporting channels for HCWs, if/when they are exposed to these infections; and iii) prompt testing and immediate post-exposure treatment for the relevant infections. This should follow the national treatment guidelines, including counseling services and offering prompt serological tests from the source patient, after informed consent has been given. If possible, the health facility should ensure that all HCWs are immunized against hepatitis B virus, varicella, measles, rubella, seasonal influenza, pertussis, tetanus, diphtheria, and polio [31]. Re-vaccination with the bacillus calmette-guérin (BCG) vaccine has been shown to offer no protection against TB, although it might provide additional protection against leprosy [41]. Policies should exist on monitoring and following up HCWs with suspected hospital-associated infections following exposure, i.e., paid medical leave. The administration must make all efforts to provide HCWs with adequate supply of personal protective equipments (PPE). Staff should be informed that it is mandatory for them to practice infection control precautions, whilst carrying out their duties in the facility.

The administration should develop policies exempting sick HCWs from work after the onset of certain symptoms, until they recover. This is especially important in cases where they have symptoms of fever associated with respiratory, diarrheal disease, and skin rash. Lack of adhering to these policies was shown to be risk factor for outbreaks of influenza in healthcare facilities [82]. HCWs must be educated to understand the risk they pose to patients and their fellow workers, if they do not adhere to this policy and abstain from work when ill. To ensure compliance, sick HCWs should still receive their salaries.

B. ENGINEERING CONTROLS

These infection control measures aimed at preventing HAIs by making the environment safe. They include infection control measures affecting hospital buildings, wards, ventilation, food, water and waste.

(i) HOSPITAL DESIGN

Whenever possible, senior medical personnel, e.g., consultants, should participate in the design and construction of hospital wards and rooms. This will allow them to provide infection control advice, in the designing of hospital wards, and consultation and operating rooms. Hospital rooms should have adequate natural ventilation, facilitated by several large windows. High wall air inlets, and low wall air outlets should be constructed in each room. This allows clean air to move downwards to the floor where it is removed through the low air outlet. Windows should be left open; though window screen meshes should be used to prevent mosquitoes from entering the wards. Rooms must be of a reasonable size so as to cater to an expected high patient load and segregation of infectious patients. Hand washing facilities should be present in every patient care room. Access to in-patient and high risk areas should be restricted; this can be enforced by enclosing these areas with a fence, and placing lockable gates. In-patient facilities should be situated far away from the main gate, so as to manage traffic and restrict access. Sensitive areas, like the kitchen, should be located away from contaminated areas. Building floors and walls should be made from material that is easy to clean and resistant to cleaning agents. Whenever constructions or renovations take place, patients should not be exposed to pollutants. They should be moved to temporary wards/tents, until the renovations are completed.

(ii) VENTILATION

Fresh circulating air in hospital rooms is important for eliminating bad odors and getting rid of harmful airborne bacteria. A well-ventilated room has been shown to be an adequate option for preventing airborne infections [31]. In addition, ultraviolet light is germicidal to the *M. tuberculosis* bacilli [41]. Negative pressure rooms are impractical in refugee camps and post-conflict settings because of cost-implications. However, most refugee camps are located in areas with plenty of sunlight; hence this is a cost-effective measure to prevent spread of TB.

Thus, all wards should have plenty of windows opening and remaining open to the outside. These windows permit sunlight to penetrate through them. If rooms are already constructed, in high risk rooms, a strategically placed mechanical fan can be used to create unidirectional airflow, towards an open window [57]. However, care should be taken since fans can aid transmission of airborne infections. TB wards should have exhaust fans that are placed to assist in improving unilateral flow of air from the rooms to the outside. This could be enforced if the wards do not have recommended large windows allowing for adequate natural sunlight and ventilation.

Facilities with operating rooms (high risk area), **MUST** install ventilation systems, which meet the air quality standards, recommended by WHO [31]. It is important for doors leading from high risk patient wards, and to the general hospital, to remain closed at all times, so as to prevent transmission of airborne diseases [31].

(iii) CLEANING OF THE HEALTHCARE ENVIRONMENT

It is important for the healthcare facility to maintain a clean environment. It has been reported that 90% of micro-organisms are present in visible dirt or dust; these can be eliminated by routine daily cleaning of the facility, with soap and water [57]. However, environmental testing for pathogens is not recommended, unless in special circumstances, i.e., outbreak investigations [31]. The cleaning staff should be well supervised, so as to ensure that the facility is adequately cleaned. The facility should have written policies indicating the frequency of cleaning and cleaning agents to be used on all surfaces, rooms and equipments. Excessive use of harmful chemical disinfectants should be avoided, since it may present a danger to human and environmental health. Cleaning should be done with clean water and soap. If soap is not available, hot water (80°C) provides an effective alternative for environmental cleaning [31]. Only damp or wet mopping or dusting should be done; dry sweeping of hospital wards is not recommended, because it increases the transmission of HAIs [57]. All surfaces should be cleaned with water and disinfectant. Administrative office areas, with no patient care activities or contact, should be cleaned once a day; if this is not possible, then at least weekly. Operating rooms should be cleaned before any procedure, between procedures, at the end of the working day; thorough cleaning should be done once a week. TB wards, isolation wards, or any ward that has patients with infectious diseases, should be cleaned daily with a disinfectant and clean waters. Laboratories should be cleaned according to specified guidelines [83].

(iv) WASTE MANAGEMENT

Healthcare facilities produce a huge amount of waste, most of which, is not risky to human health; with the exception of sharps contaminated with blood [57]. This waste consists of: i) infectious, ii) pharmaceutical, iii) sharps; iv) pathological (human tissue/fluid), v) heavy metals (batteries, thermometer), vi) paper, and vii) pressurized containers (gas cylinders) [31]. It is important for each type of waste to be disposed of in an appropriate manner. Each facility should have written policies, indicating the treatment and disposal of each type of healthcare waste. Efforts should be made to minimize the amount of waste generated by the health facility, e.g., paper, unnecessary injections. The administration should provide means of waste disposal that are accessible and convenient for staff. There should be a system in place to ensure that staffs adhere to appropriate waste disposal. This could be done with the help of supervisors of respective units in the facility and included with other training to change staff's attitudes and behavior as regards to infection control practices.

Clinical waste should be collected in separate containers from non-clinical waste; the containers should be lined with identifiable plastic bags (biohazard marker/ color coded). Different locally available containers can be used in place of costly equipment. Garbage should be collected daily, and transported in specific trolleys. There should be a designated restricted area in the facility for waste storage. Sharps, i.e., needles, cover glasses, glass slides, should be collected at the point of use, in non-collapsible, impenetrable, puncture resistant, narrow mouths containers (metal/ sturdy plastic/ thick cardboard), which are leak proof on the sides and bottom. The containers should not be overfilled; once two-thirds full, they should be closed and buried in a secure area-2-3 meters deep and 1.5 meters above the groundwater table, or incinerated [57]. Infectious, pathological, and laboratory waste (except mercury), should be incinerated. Mercury waste (i.e., batteries) should not be incinerated. Kitchen waste should be placed in a compost heap, which is properly maintained to prevent rats and other animals.

HCWs responsible for handling waste should be trained on the hazards presented by healthcare waste and should wear appropriate PPE. The facilities should follow guidelines for handling of dead bodies/tissues and their disposal with consideration and respect for local practices and beliefs. There should be a separate holding area for dead bodies, which should be secure and located away from patient care areas while awaiting their collection.

(v) HEALTHCARE LINEN AND BEDDINGS

Used hospital linen, should be collected in designated impermeable bags/containers at the point of use. The bags should then be closed and secured; clothes should not be sorted whilst in the wards or near patients. There should be minimal tossing around during transportation. Used sheets and blankets are to be washed in hot water (70-80°C) and detergent, rinsed, and then left to dry in the sun. Linen for use in the operating room must be autoclaved [57]. Hospital facilities providing surgical services must have an autoclave machine. Hospital mattresses and pillows should be covered with plastic covers for ease of cleaning between patients.

(vi) INSTRUMENTS AND EQUIPMENTS

HAIs can be transmitted from contaminated instruments and equipment depending on: i) presence of micro-organisms on the instruments, ii) type of procedure to be performed with the instrument, and iii) the body site where the instrument will be used [57]. Therefore, it is important to disinfect and sterilize instruments after one use. All instruments must be cleaned immediately after use, with soap and water, in order to remove organic matter, i.e., blood, secretions, soil. This step is sufficient for bedside sinks. Hot water can be used as a substitute for soap. All instruments/equipments coming into contact with a sterile body part must be sterilized by steam or chemicals, e.g., surgical instruments, IV catheters. All instruments/equipment coming into contact with mucous membranes/non-intact skin must be disinfected by appropriate chemicals, e.g., resuscitation equipments.

Chemical disinfectant used must be specific for equipments, e.g., glutaraldehyde 2%, hypochlorite; do not use household disinfectant to clean hospital instruments [31]. Hypochlorite must be diluted to solutions of 0.5%, 1% and 2%. These solutions must be prepared daily or when they become dirty or cloudy [84]. Sterilized instruments must be packaged or wrapped, and allowed to dry before removal from the autoclave; they must remain unopened until point of use. Medical equipment and instruments should be disinfected before being sent for service or repairs. If there is no autoclave in the health facility, instruments can be cleaned and put through one cycle in a pressure cooker for 30 minutes [57]. This provides adequate sterilization. Medical devices should not be boiled for re-use, because this is not an effective sterilization method. Cleaning mops should be washed with hot water immediately after use and dried in the sun; they should not be stored while wet [57].

(vii) HAND WASHING FACILITIES

Hand washing has been hailed as the single most important measure to reduce the risks of transmitting micro-organisms from one person to another, or from one site to another on the same patient [35]. It is an integral component of infection control programs. In 1840, Ignaz Semelweis demonstrated the importance of hand hygiene in controlling infections in an obstetric ward. Numerous studies conducted in the past decades have also shown how a variety of hand hygiene methods can significantly reduce bacterial load and prevent cross transmission and HAI [85]. An early prospective controlled trial conducted by Mortimer, et al demonstrated that infants cared for by nurses who did not wash their hands after handling an index infant colonized with *S. aureus*, acquired the organism significantly more often and more rapidly, than those cared for by nurses who used hexachlorophene to clean their hands between infants, thus providing compelling evidence for efforts to improve hand hygiene among HCWs [86]. A similar observation was made in a Swiss hospital where it was shown that there was a high level of transmission of *S. aureus* from staff members to infants [87]. This high level of transmission was noted among staff who did not comply with proper hand washing recommendations and protocols. Although hand hygiene is a simple act that should be routine among HCWs, data from worldwide studies show that compliance is universally low [29]. Low rates of hand washing compliance and adherence by health workers, especially clinicians, have been reported in both developed and developing countries.

Alcoholic hand rubs that overcome the time problem of washing hands, are suitable for use in facilities lacking hand washing infrastructure. It takes approximately 45 to 90 seconds to wash hands with soap and water, while using a hand rub takes less than 30 seconds and enhances killing of transient hand flora. It is more accessible, convenient to use and has a pleasant odor [88]. Facilities should make an effort to locally manufacture alcoholic hand rubs using the WHO formula, and avail it in all patient care area (http://www.who.int/patientsafety/events/05/HH_en.pdf). Staff and patients should be taught to air-dry their hands after hand washing; not dry them on their clothes. There should be illustrated hand washing protocols displayed in all hand washing stations with instructions on the 'WHO 5 steps of handwashing' [29].

(viii) DRINKING WATER

The healthcare facility should provide safe drinking water, which meets local water safety regulations. Drinking water should be chlorinated or boiled for 5 minutes. Water purifiers also can be used. Water storage container should have a narrow mouth, or have an outlet/device/tap for dispensing water. This prevents contamination by hands or other devices. Water tanks and storage containers should be cleaned regularly. A minimum amount of 15 liters of water/person/day should be provided according to the SPHERE guidelines [19].

(ix) SANITATION FACILITIES

Improperly cleaned baths have been shown to be associated with several infections including *Pseudomonas aeruginosa,* which causes severe infections in immunocompromised people [31]. Given that resource-limited settings have frequent water and staff shortages, it is preferable that they provide showers for patients. Toilet facilities should be constructed in accessible areas, but far from sensitive areas like the kitchen, so as to avoid contamination of food and drinking water. There should be adequate numbers of latrines, to service the HCWs, patients and family members. In acute emergencies, the minimum should be 1 latrine/50 people, reducing to 1 latrine/20 people as the crisis stabilizes [19]. There should be separate male and female toilets/latrine facilities for patients and HCWs. Patients with infectious diseases, in isolation and those with diarrheal disease should ideally have their own latrines. Sanitation facilities should be cleaned regularly to ensure hygiene. Cleaning staff should be provided with PPE. Full latrines should be filled in properly. Latrines and toilets should be cleaned daily.

(x) PEST CONTROL

Because of the high burden of vector borne diseases facing most resource-limited settings, it is important for healthcare facilities to have pest control measures. Facility should have precautions for avoiding mosquitoes, e.g., insecticide residual spraying (IRS), destroy uncovered water swamps, and provide patients with long lasting insecticide treated mosquito nets. Traps should be set for control of rodents, especially in the stores and wards where food material is present. Thick bushes should be trimmed and grass cut.

(xi) FOOD

Hospitals usually prepare food in large quantities (mass catering), which is a risk factor for food borne illnesses [31]. Inappropriate handling of food, may lead to a widespread outbreak within the facility. Therefore, steps should be taken to ensure proper hygiene standards are maintained. Facilities with no refrigeration equipment, should not prepare food more than a half a day in advance. Perishable food should not be stored at room temperature. Food must be cooked well; undercooking may cause infections. The kitchen area must be clean at all times. Raw food should be separated from cooked food to avoid contamination. Perishable home-cooked food brought by family members, should not be allowed to stay overnight.

Food handlers must observe high standards of personal hygiene, especially hand washing; they must wear protective clothing while cooking (hair should be covered), and must undergo routine medical examinations for communicable diseases. They should receive ongoing training on safe food handling practices. There should be a policy established in the facility, preventing sick food handlers from accessing the kitchen area or preparing food.

C. PERSONAL PROTECTION EQUIPMENT (PPE)

PPE as defined by the United States, Occupational Safety and Health Administration (OSHA), are “specialized clothing or equipment worn by an employee for protection against infectious materials.” These are worn during healthcare delivery to prevent HCWs from exposure to infectious pathogens [72]. PPEs commonly used in most U.S. healthcare facilities are: i) gloves used to protect hands, ii) gowns used to protect skin and clothing, iii) masks to protect the mouth and nose, and iv) goggles used to protect the eyes. Standard and additional infection control precautions provide guidance on conditions necessitating usage of PPEs. In addition, CDC and WHO have produced several guidelines on the use of PPE to prevent exposure to infectious diseases, and reduce HAI transmission in healthcare settings [37]. Whenever possible, HCWs, patients and patients’ family members should utilize PPE correctly and at all times where there is contact with any infectious materials [57]. This information must be made available to all staff, in order for them to know the dangers and risks they face in their routine duties. The facility should have written policies guiding HCWs on proper usage of PPE.

Gowns and plastic aprons are worn to protect the HCW’s clothes and body from contamination. They can be sterile (if worn during surgeries), or clean, and are used when contamination of the arms or trunk is expected. Aprons provide limited protection, and are often worn on top of the gown to prevent fluid penetration [57]. During surgeries, sterile gowns are worn to protect the whole body. To cut costs, sterile gowns can be made from locally available cotton cloth and re-used, but only after sterilization. Plastic aprons are re-usable, but should be cleaned with disinfectant, after each use.

Gloves are the most commonly used PPE in healthcare facilities. There are also sterile and non-sterile gloves. HCWs should wear gloves when attending to patients where they have risk of contact with body fluids, or performing other duties. They provide a protective barrier against gross contamination of hands when touching body fluids or secretions. They also protect the patients against contact with pathogens that may be present on the HCWs hands. However, they are not a substitute for appropriate hand washing. They are made of different types of material, i.e., vinyl, latex. All gloves should be strong and not easily torn exposing the HCW to infectious material. Facilities should purchase gloves for different sizes so as to ensure that HCWs put on well fitting gloves, failure to do so could contribute to needle stick injuries and accidents. As a way of cutting costs, sterile gloves, could only be used in 'high risk' invasive procedures, e.g., surgeries, obstetric deliveries, wound cleaning, nursery. The non-sterile gloves can then be used in routine medical duties. Environmental cleaning staff should be provided with re-usable heavy duty gloves to work with. These are hardier and provide adequate protection. The gloves should be cleaned and disinfected after each use. HCWs should receive adequate re-training on proper glove usage. As soon as a glove is used, it becomes contaminated, and can be a means of spreading HAIs to other patients and the environment. It is a well established fact that inanimate surfaces surrounding infectious patients contain pathogens and HCWs can contaminate their gloves/hands thus spreading infections to other patients [36]. Glove wearing HCWs should practice the basic infection control practice of touching clean body sites or surfaces prior to touching dirty, contaminated surfaces [1]. They should work from clean to dirty areas, and avoid touching their bodies, clothes or other surfaces, e.g., doors, tables whilst donning gloves to avoid contamination. Gloves should be changed when torn or visibly dirty. Ideally, they should be used on only one patient and never reused or washed. Though effective, wearing gloves should not be used as a substitute for hand washing; this is because gloves may have small, unseen perforations, which could cause contamination of hands [35]. Contaminated parts of the PPE should be avoided when removing them. Only clean parts of PPEs should be touched, e.g., inside of gloves, back of gown.

Masks are worn to protect HCWs' nose and mouth. Ideally, they should cover the nose and mouth fully in order to be effective. This can be accomplished with the use of elastic strings placed on either side of the mask, secured on the head over the ears. Disposable masks should not be re-used. Most resource-limited countries and refugee camps, cannot afford to purchase expensive respirator masks with high-efficiency particulate air filters (HEPA), which prevent inhaling droplet nuclei of 1-5 micrograms. Therefore, administrative and engineer measures must be enforced, i.e., diagnosing infectious patients as soon as possible, separating them from other patients, examining patients only in well ventilated areas, having the patients with airborne infections wear surgical masks as much as possible (especially when in contact with other patients or staff). While surgical masks have been shown to be ineffective (50% efficacy) in preventing inhalation of harmful droplets nuclei, they are effective at preventing the exhalation of particles, hence should be worn by TB patients, with productive cough whenever they are outside their isolation wards or when HCWs are present [41]. PPEs are worn and removed in the sequence illustrated in Figure 6 [28].

Laboratory staff should be provided with barrier garments, gloves .and training on how to deal with contagious samples. They could wash the exterior of the sputum containers with household bleach if there is no safety cabinet in the facility.

D. SURVEILLANCE AND LABORATORY

Surveillance of HAIs should be initiated within healthcare facilities, and made a priority. This will enable the scale of the problem to determined and monitor trends to give a picture on the effectiveness of infection control programs and various interventions. Surveillance is the only way to provide evidence that changes are actually leading to an improvement and reduction in HAIs. A qualified infection control staff, with good epidemiological skills should be hired to manage surveillance data, analyze reports, interpret findings, and provide timely feedback to staff. In this endeavor, donor agencies or CDC/WHO can be requested to provide technical support. Basic, cost-effective passive surveillance systems should be developed to monitor and detect HAIs, especially in high risk areas like the acute surgical and obstetric wards. Standardized clinical case definitions of HAIs should be developed so as to ensure reliability of surveillance data. It will also ensure comparisons with local and international HAI rates. In facilities where laboratory facilities are not available, a senior physician or surgeon's diagnosis of infection derived from direct observation diagnosis or clinical judgment is an acceptable criterion for an HAI. Post-operative patients should be followed up in surgical outpatient clinics after discharge to monitor for signs of sepsis and fever. The patient's relatives should also be educated on simple warning signs of infection such as redness, tenderness, swelling at incision site so as to bring back the patients to hospital in a timely manner in the event that they observe these signs. This will aid in reducing morbidity and mortality by facilitating patient's early presentation in healthcare facilities to receive medical attention.

In establishing the surveillance activities, protocols should be developed detailing the activities and desired outcomes. Baseline surveys are useful in establishing the magnitude of the problem in the facility. These would involve collection of clinical data with laboratory surveillance data. Weekly review of patients for morbidity and mortality associated with HAIs should be instituted in the facility, especially in high risk areas. During these meetings, HCWs can receive feedback from the infection control staff on surveillance data findings. This will be an appropriate venue for identifying feasible infection control measures based on the surveillance data. Consequent follow up audits would be helpful in measuring results and assessing the impact of the infection control interventions.

Quality microbiological laboratory support is essential for any successful infection control program. Laboratory staffs are in a position to provide leadership and assist in the development of effective infection control teams. They should assist in the interpretation of laboratory results, provide infection control advice, and sometimes guide antibiotic therapy. These studies will establish diagnostic capability and build clinical expertise in basic clinical microbiology in the laboratory staff. They also will raise awareness amongst the staff on the presence of harmful pathogens in the facility [5]. However, the hospital management must be willing to fund these studies for the efforts to be successful and the benefit to be long standing and sustainable. Table 6 provides a summary of the recommended infection control practices applicable in resource-limited settings and refugee camps.

Finally, effective monitoring and evaluation tools for infection control practices in refugee camps and post-conflict settings need to be developed to assess use of infection control guidelines and their effectiveness in reducing HAI transmission within healthcare facilities located in refugee camps and post-conflict settings. They should be based on cost-effective infection control measures that can be implemented in these settings.

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VIII. APPENDIX

Figure 1: Location of Kisii District and Kakuma Hospitals

Figure 2: Modes of Infection Transmission within Healthcare Facilities

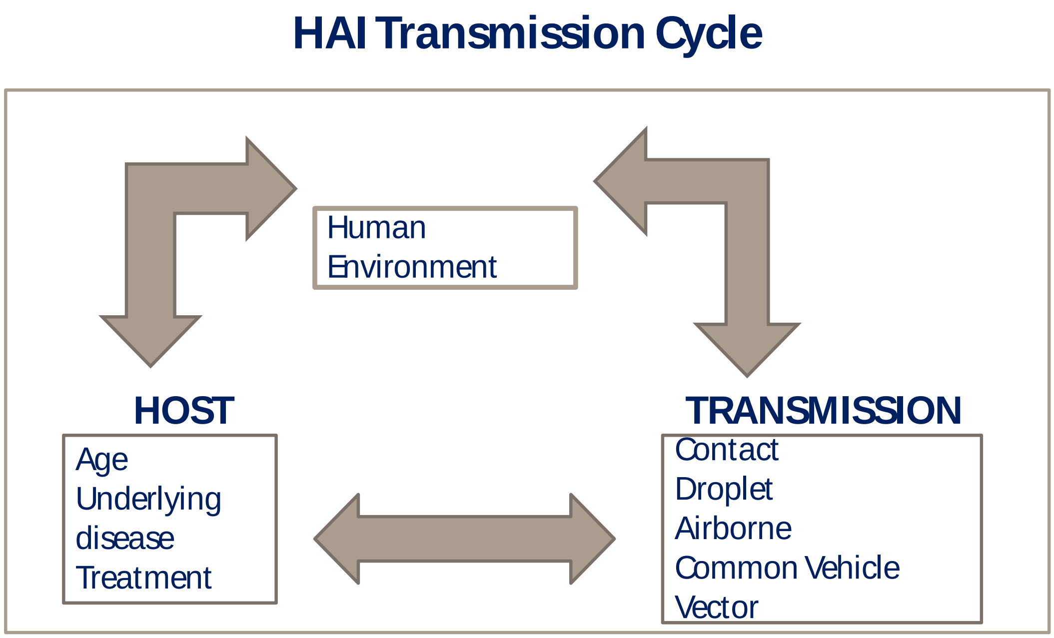


Figure 3: Flow diagram for selection of articles

Table 1: Classification of articles according to region

WHO Region	Number	Frequency (%)
Africa	6	22.22
Southeast Asia	3	11.11
Americas	5	18.52
Eastern Mediterranean	5	18.52
Western Pacific	5	18.52
Eastern Europe	3	11.11
Total	**27**	**100%**

Table 2: Classification of articles according to type of study

Type of study	Number	Frequency (%)
Prevalence	11	40.7
Prospective	16	59.3
Total	**27**	**100%**

Table 3: Overall Healthcare-associated infections

Author	Country/ Region	Sample size (Denominator)	Finding (Numerator)	HAI Rate/100 patients
Faria et al(2003)	Albania	968	163	16.84
Maksimovic J et al(2002)	Serbia	277	63	22.74
Noelia L et at(1993)	Brazil	7847	1050	13.38
Danchaivijitr S et al(2006)	Thailand	9865	22	0.22
Jepsen OB et al(1992)	Mauritius	1190	59	4.96
Shabir AM et al(2001)	Africa	130	15	11.54
Gedebou M et al(1984)	Ethiopia	700	119	17
Cicirello HG et al	India	169	65	38.46
Boo NY et al(1991)	Malaysia	935	49	5.24
Littaua R et al(1985)	Philippines	3915	173	4.42
Duerink DO et al(2001)	Indonesia	2290	163	7.12
Mitt P et al(2002)	Estonia	305	19	6.23
Eltahawy AT et al(1992)	Saudi Arabia	1418	128	9.03
Cardoso DM et al(2009)	Brazil	187	44	23.53
Kaplan NM et al(2003)	Jordan	1319	107	8.11
Habib FA et al(2000)	Saudi Arabia	754	34	4.51
Chukudebelu WO et al (1983)	Nigeria	1988	51	2.57
Soleto L et al(1999)	Bolivia	376	46	12.23
Hernandez K et al(1998)	Peru	468	125	26.71
Ezechi OC et al(2009)	Nigeria	817	76	9.30
Juuko G et al(2001)	South Africa	270	33	12.22
Sohn AH et al(2001)	Vietnam	391	56	14.32
Xie DS et al(2008)	China	20350	833	4.09
Hughes AJ et al(2001)	Malaysia	538	75	13.94
Orrett FA et al(1995)	Trinidad and Tobago	72532	7158	9.87
Jroundi I et al(2007)	Morocco	658	118	17.93
Dhutta P (1986)	India	189	36	19.04

Median= 11.5

Mean= 12.4 95%CI: (9.05, 15.81)

Table 3-B: Surgical-site infection

Author	Country		SSI rate/100 patients
Chekudebelu et al (1983)	Nigeria	0.026	2.6
Gedebou et al (1984)	Ethiopia	0.47	47.0
Eltahawy et al (1992)	Saudi Arabia	0.09	9.0
Hernandez et al (1998)	Peru	0.26709402	26.71
Soleto et al (1999)	Bolivia	0.12	12.0
Juuko et al (2001)	South Africa	0.119	11.9
Hughes et al (2001)	Malaysia	0.015568	1.56
Sohn et al (2001)	Vietnam	0.143	14.3
Habib et al (2000)	Saudi Arabia	0.045	4.5
Maksimovic et al (2002)	Serbia	0.227	22.7
Mitt et al (2002)	Estonia	0.062	6.2
Faria et al (2003)	Albania	0.04091839	4.09
Kaplan et al (2003)	Jordan	0.081	8.1
Xie et al (2008)	China	0.0037248	0.37
Ezechi et al (2009)	Nigeria	0.09302326	9.30
Cardoso et al (2009)	Brazil	0.23529412	23.53

Mean= 12.7 95% CI: (6.28, 19.20)

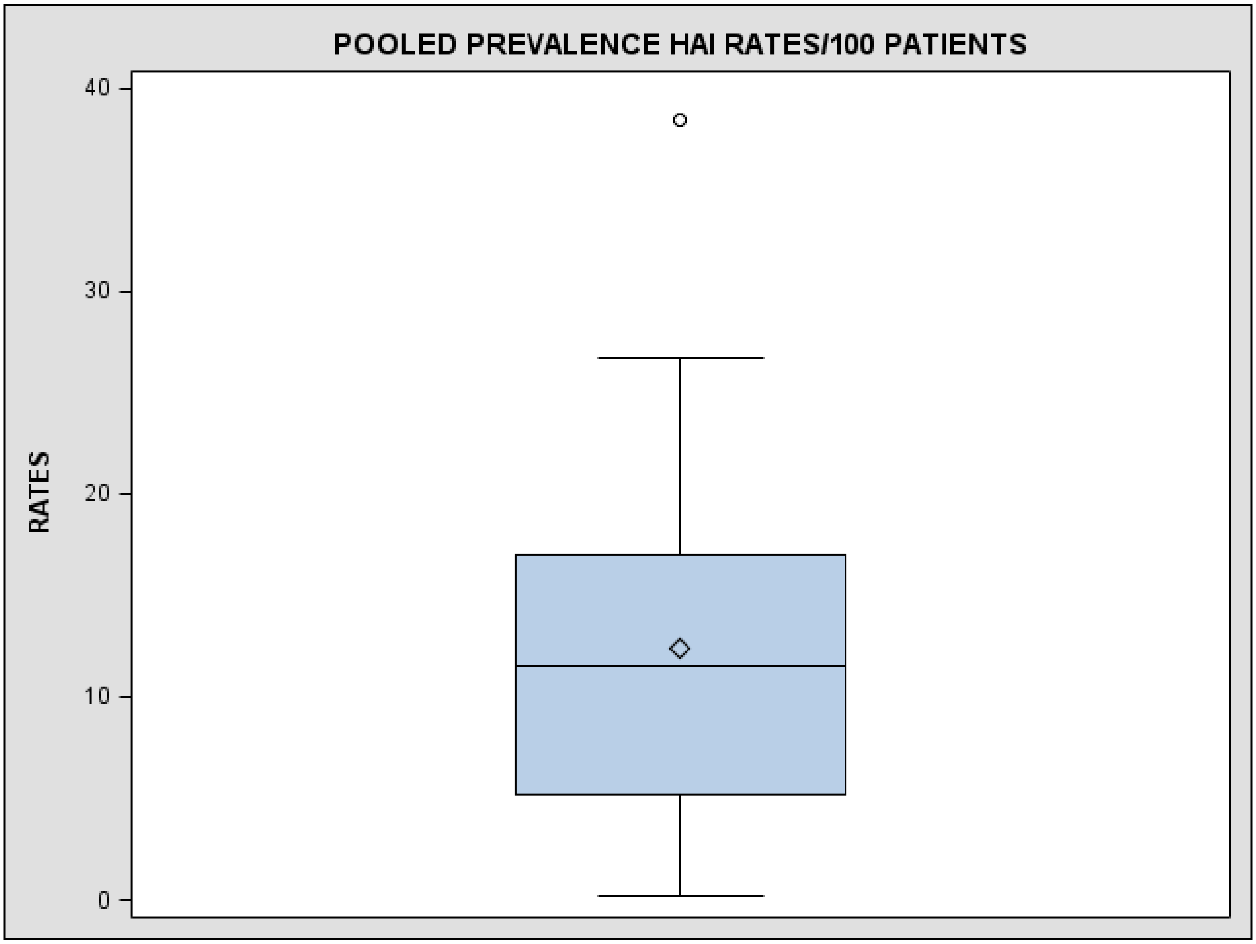
Median= 9.2

Table 3-C: Urinary-tract infection

Author		Rate/100 patients
Gedebou et al (1984)	0.0255	2.55
Duerrink et al (2001)	0.035	3.5
Hughes et al (2001)	0.016958	1.7
Faria et al (2003)	0.055572	5.56
Jroundi et al (2007)	0.0623	6.23

Mean= 3.9 95% CI: (1.50, 6.31) Median=3.5

Figure 4: Box-plot of pooled HAI prevalence rate in resource-limited settings as reported in table 3-A; (1983-2009)



X-axis=rates/100 patients

□ 25%-75% (5.74, 16.92)

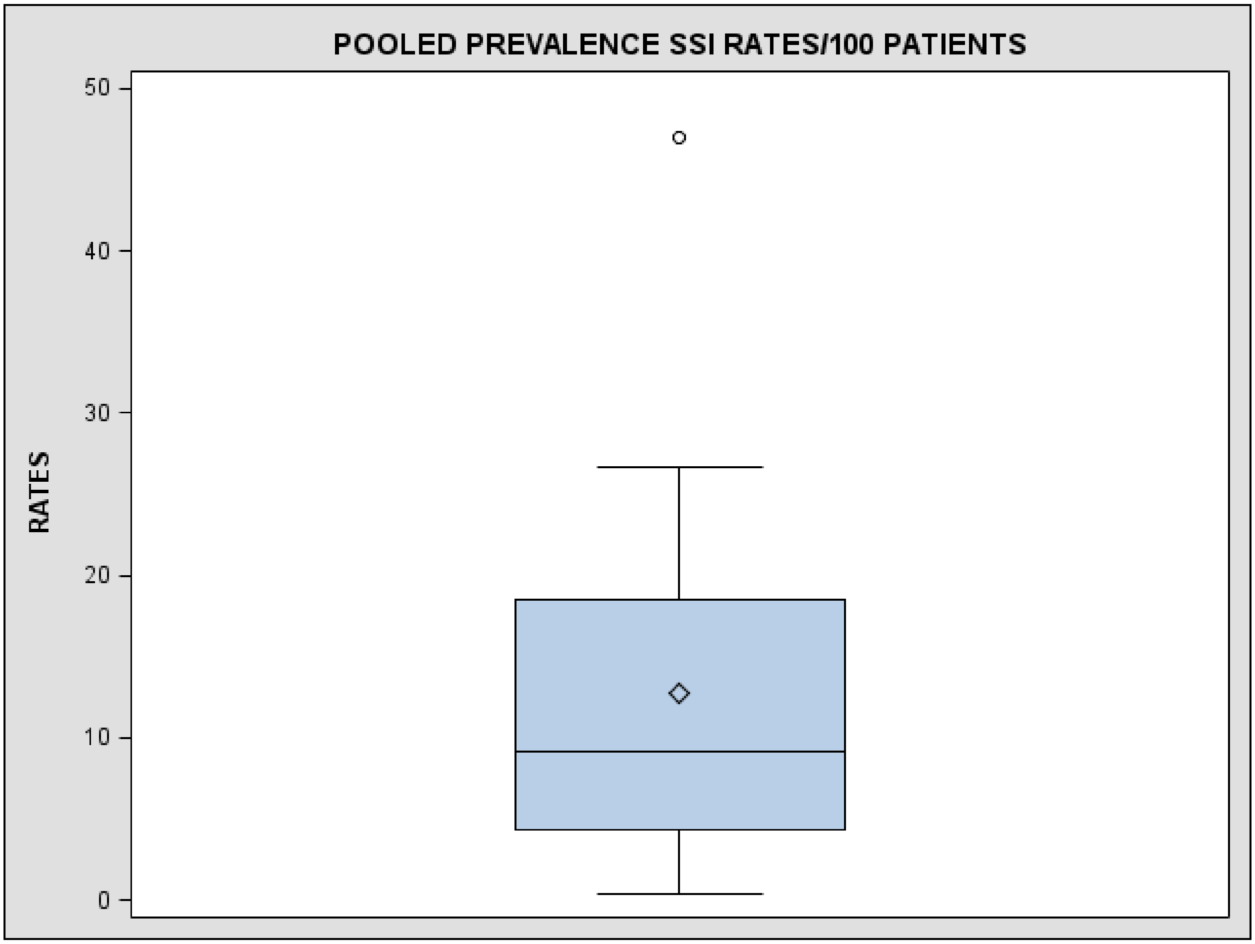
Range (0.22, 38.46)

◇ Mean (12.4)

— Median (11.5)

○ Outlier

Figure 5: Box-plot of pooled SSI prevalence rate in resource-limited settings as reported in table 3-B; (1983-2009)



X-axis=rates/100 patients

25%-75% (4.4, 16.4)

Range (0.37, 47.0)

Mean (12.7)

Median (9.2)

Outlier

Table 4: Infection Control Guidelines Practical to Resource-limited Settings

Results: Guidelines

Title	Strengths
WHO guidelines on Hand Hygiene in Health care, 2009	• Hand hygiene compliance •Improve infrastructure •Education •Knowledge
WHO Practical Guidelines for Infection Control in Health care, 2004	• Prevention of HAI •Comprehensive •Adapts international guidelines •Special diseases
Infection Prevention Guidelines for Health care Facilities with Limited Resources(JHPIEGO), 2003	• Modifies international guidelines •Comprehensive •Education material •Assessment manual

Results: Guidelines

Title	Strength
CDC guidelines for Hand Hygiene in Healthcare Settings (2002)	• Promote hand washing • scientific evidence •Hand hygiene •Product efficacy
Prevention of Hospital- acquired infections (WHO), 2002	•Overview of HAIs • Infection control committee •Surveillance •Antimicrobial resistance
Infection Prevention: A reference booklet for Health care Providers (Engender Health), 2001	• comprehensive •Hand book •Practical •Step by step

Table 5: Observed Causes of Healthcare-associated infections (HAIs) in Kakuma and Kisii hospitals

Among Healthcare workers (HCWs)

1. Shortage of qualified HCWs
2. Unvaccinated HCWs
3. Lack of adequate training, knowledge, competency and practice among HCWs
4. Lack of good hygiene practices, i.e., handwashing, environmental cleaning, use of protection protective equipment (PPE), aseptic techniques
5. Lack of awareness and commitment among hospital administrators and management.

Essential supplies and equipment

1. Lack of essential equipment and supplies, i.e., soap, surgical instruments, gloves, sterilizers
    - Inadequately cleaned supplies with re-use of unsterile supplies
    - Sharing of IV medication/ fluids between patients
2. Inadequate water supply
3. Frequent drug and supplies stock outs
4. Lack of quality control measures in the sterilization/ disinfection of multi-use instruments

Hospital structure

1. Lack of isolation facilities
2. Overcrowding
    - Unwarranted hospital admissions
    - Inadequate crowd control
3. Misuse of antibiotics
4. Inadequate microbiology laboratory capacity
5. Lack of surveillance systems
6. Delays in diagnosis and treatment of patients
7. Crowding of surgical theaters by student trainees and surgical staff
8. Lack of established infection control program/ institutional system to deal with HAIs

Figure 6: Sequence for wearing and removing Personal Protective Equipment (PPE)

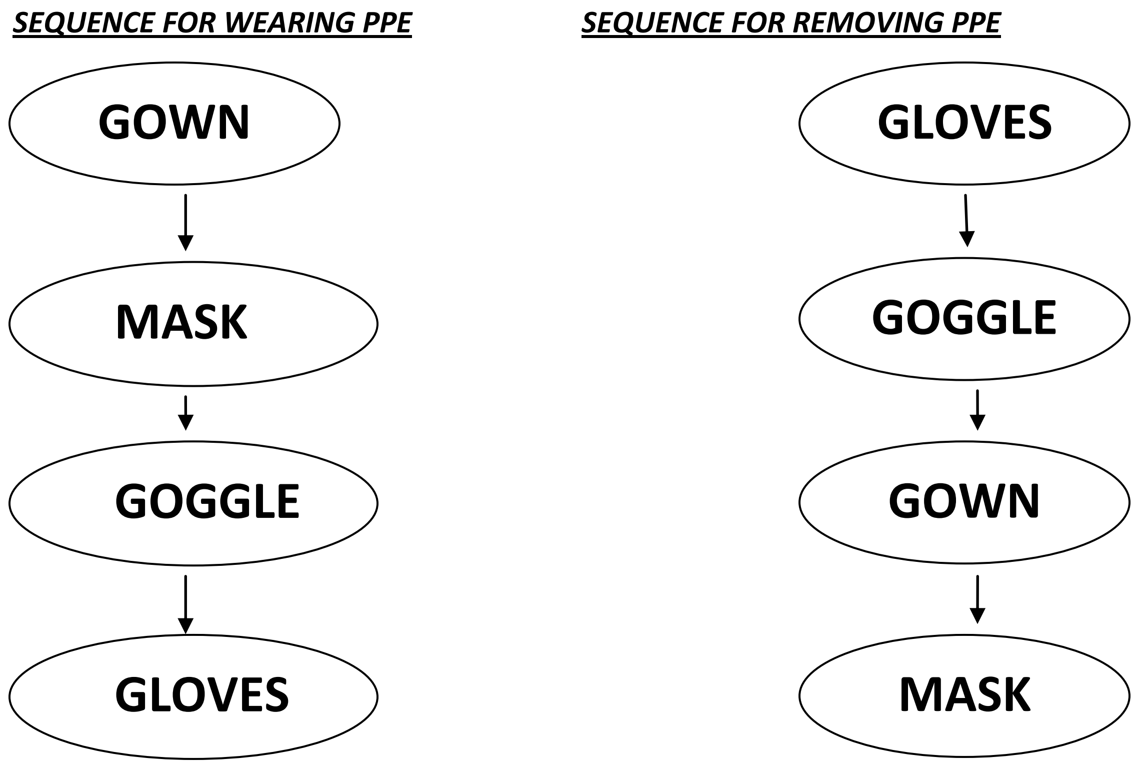


Table 6: Summary of Infections Control Recommendations for Post-Conflict Settings and Refugee Camps

1. Administrative

1. Training and education of healthcare workers (HCWs), patients and / or family members
    - Increase awareness of healthcare-associated infections (HAIs) and use of infection control practices
    - Appropriate antibiotic use
    - Avoid invasive medical procedures
2. Reduce hospital admissions
    - Investigate as out-patients
    - Establish admission-discharge criteria
    - Rapid diagnosis and appropriate treatment
    - Hire support staff
3. Infection prevention and control policies
    - Infection control committee and manual
    - Establish surveillance system
    - Improve microbiology laboratory capacity
    - Initiate weekly morbidity and mortality reporting
4. Implement practical precautions during patient placement and transportation
    - Use of temporary tents and patient cohorting
    - Outside waiting rooms

2. Engineering

1. Improve natural ventilation
    - Create large windows, air vents and mechanical fans
2. Handwashing
    - Hand washing facilities or alternative methods where feasible
3. Environmental issues
    - Damp mopping, use of hot water
    - Quality control in instrument processing
    - Pest control, e.g., insecticide residual spraying(IRS), destruction of water swamps and rodent traps
4. Waste management
    - Reduce waste generation
    - Use of separate containers for medical and non-medical waste
    - Proper sharps disposal
5. Food handling
    - Proper hygiene practices
    - Storage

3. Personal Protective Equipment (PPE)

1. Make PPE from local materials
    - Cost-effective, e.g., plastic gowns, aprons, re-usable head nets
    - Long lasting insecticide treated mosquito nets
    - Immunization of HCWs