SURVEILLANCE OF RESPIRATORY VIRAL HEALTHCARE ASSOCIATED INFECTIONS (RHAI) AMONGST INPATIENTS IN SELECTED HOSPITALS IN KENYA

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Surveillance of Respiratory Viral Healthcare associated infections (rHAI) amongst inpatients in selected Hospitals in Kenya

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university.

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DEDICATION

To my beloved wife Phides Wanjagi Kirimi and our daughters Hilda Wachuka Kirimi and JoyFridah Kendi Kirimi.

To my parents, Joseph Ndegwa Ibutu, Margery Igoki Ndegwa and the memory of my late grandfather, Francis Ibutu, who always instilled the value of hard work and honesty.
To all the study subjects who suffered from respiratory healthcare associated infections (HAIs)

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LIST OF ABBREVIATIONS AND ACRONYMS

AIDS	Acquired ImmunoDeficiency Syndrome
ANA	Association of American Nurses
aOR	Adjusted Odds Ratio
ARI	Acute Respiratory Illness
BSI	Blood Stream Infection
CDC	Centres for Disease Control
CI	Confidence Interval
C_T	Cross-over Threshold
ENT	Ear, Nose and Throat
ERC	Ethical Review Committee
et al	And Others
FCGs	Family Caregivers
HAdVs	Human adenoviruses
HAI	Healthcare-associated infection
HCW	Health Care Workers
HCW	Healthcare Workers
HH	Hand Hygiene
HIV	Human Immunodeficiency Virus
HMPV	Human MetaPneumoVirus
ICU	Intensive Care Unit
IEIP	International Emerging Infections Program
IFIC	International Federation for Infection Control
ILI	Influenza-like Illness
IPC	Infection Prevention and Control
IV	Intravenous
JKUAT	Jomo Kenyatta University of Agriculture and Technology
KEMRI	Kenya Medical Research Institute
KNH	Kenyatta National Hospital

LRTI	Lower Respiratory Tract Infections
MDH	Mbagathi District Hospital
MMWR	Morbidly & Mortality Weekly Report
MOH	Ministry of Health
NC	North Carolina
NHS	National Health Services
NI	Nosocomial Infections
NICU	Neonatal Intensive Care Unit
NNPGH	New Nyanza Provincial General Hospital
NP	Nasopharyngeal
OP	OroPharyngeal
OR	Odds Ratios
PCR	Polymerase Chain Reaction
PDA	Personal Digital Assistant
PGH	Provincial General Hospital
PIV	Para Influenza Virus
RIDD	Respiratory Infectious Disease Department
RNA	Ribonucleic Acid
RSV	Respiratory Syncytial Virus
RTI	Respiratory Tract Infection
rtRT-PCR	real-time Reverse Transcription-Polymerase Chain Reaction
SAS	statistical analysis systems
SD	Standard Deviation
SENIC	Study on the Efficacy of Nosocomial Infection Control
Spp	Species
SSC	Scientific Steering Committee
STIs	Sexually Transmitted Infections
USA	United States of America
VTM	Viral Transport Media

WHO World Health Organisation

OPERATIONAL DEFINITIONS

Healthcare associated infections: infections that develops in a patient 72 hours or more after admission to a hospital and within 10 days after hospital discharge or within 48 hours after insertion of an indwelling device, such as a urinary catheter.

Respiratory healthcare associated infections (HAIs): new onset of fever ($>38^0$C) or hypothermia ($<35^0$C) with new onset cough, sore throat or other respiratory symptoms not present at the time of admission occurring after 72 hours of hospitalization.

Nosocomial infections: refers to those infections associated with admission in an acute care hospital

Patient-days: total number of days of hospitalization for all patients at risk (i.e., the sum of the number of days that each patient was admitted during the study period)

Incidence rate: the number of new respiratory HAIs divided by the number of patients at risk during the study period

Incidence density: the number of new respiratory HAIs divided by the number of patient-days at risk during the period of surveillance (study period)

ABSTRACT

Respiratory pathogens are highly transmissible in hospital settings, especially those without adequate infection prevention and control (IPC) programs. Although rates of healthcare-associated infections (HAI) in Kenya are suspected to be high, little data exists. Respiratory HAIs was evaluated from 1st September 2009 to 31st July 2010 in three hospitals in Kenya to determine the incidence of, and the risk factors associated with respiratory HAIs. During the study, in each of the selected wards, patients with respiratory HAI were identified, as any patient who developed new fever ($\geq 38^0$C) or hypothermia ($<35^0$C) in the hospital ($\geq$3days after admission) with concurrent clinical features of acute respiratory infection. Nasopharyngeal and oropharyngeal specimens were collected from these patients and tested by real-time reverse transcription polymerase chain reaction for eight viruses. No follow-up occurred after patients were discharged. From September 2009 to July 2010, a total of 406 patients identified with HAIs, were recruited, of which 155 (38.2%), had respiratory HAIs. The overall incidence of respiratory HAI was 0.80 infections per 1000 patient-days, with the highest incidence in the ICUs' (5.5/1000 patients days) followed by the eye ward (3.3/1000 patients days). Of all specimens analysed, 56 (42.1%) had at least one respiratory virus identified; 73.2% of all positive viral specimens were identified in patients ≤5 years old. Respiratory viral HAI were prevalent 79 (49.1%) in the patients' ≤5 years admitted in hospitals in Kenya, of which RSV was the most prominent. Respiratory HAI was associated with the type of ward the patient was admitted, age of the patient and having a central line catheter *in situ*. Adjusting for age and hospital, patients in ICU had 12.6 (95% confidence interval 4.7-33.9) times greater odds ($p<0.05$) of respiratory HAI. In conclusion, respiratory HAI is common in children ≤5 years of age and patients admitted in the ICU.

This gives an indication of the magnitude of the burden imposed by respiratory HAI in these groups of patients, and it should lead to increased efforts by healthcare workers to adhere to strict infection control measures to limit the spread of these infections in these patients' populations.

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Healthcare-associated infection (HAI) is a major health problem in both developed and developing countries. The occurrence of HAI is a threat to the health and safety of both patients and health care workers (HCWs). HAI infection rates are considered as an indicator of the quality of health care and also the appropriateness of infection control measures (Lazzari *et al.*, 2004) in hospitals.

A study by Allegranzi, (2011) the World Health Organization Patient Safety, and colleagues showed that HAI in developing countries occurred in 15% of patients' admissions (Allegranzi *et al.*, 2011). This is twice the HAI rates in developed nations. HAI are adverse patient events that affect approximately 2 million persons annually in USA (Edwards *et al.*, 2008).These infections are associated with increased morbidity and mortality as well as increased length of stay and costs of care (Danchaivijitrmd *et al.*, 2005).

In 2011, Allegranzi noted, HAI was poorly recorded in some regions, especially in Africa and in the western Pacific region (Allegranzi *et al.*, 2011). However, scant data suggest that in resource-poor settings, HAIs occur for 10-30% of all admissions (Pittet and Donaldson, 2005b). Major international health organizations have advocated the urgent need for research to assess the burden and implications of HAI in developing and transitional countries (WHO., 2007).

Respiratory infections accounted for more than 6% of the total global burden of disease in 2002 and represented the second most common cause of HAIs (Mizgerd, 2006).

A substantial number of viruses, bacteria and fungi are capable of causing respiratory HAI (Eickhoff, 1994). The possible sources of these pathogens are inside the hospital (infected or colonised patients, staff and visitors, infective dusts, hospital equipment, ventilation or air-conditioning systems) and outside the hospital like water, dust from construction or renovation (Donald, 2007). During the cold weather there is increased transmission of viral respiratory infections.

An important cause of morbidity and often mortality in most communities every cold season, respiratory viral infections, especially influenza, pose a special hazard inside healthcare facilities. Viral infections have a short incubation period and efficient respiratory spread from person to person; hence they can cause explosive outbreaks of febrile respiratory illness. The hospital patient population has serious underlying illnesses, making viral infections more lethal in this setting. Utilization data from health management information system (HMIS) indicate that respiratory illnesses are the second leading cause of morbidity in Kenya (Wamai, 2009).

Respiratory viral healthcare-associated infections (RHAI), is a reflection of viral activity in the community (Vayalumkal *et al.,* 2009). Transmission of viruses in the healthcare facilities is enabled by close contact of susceptible individuals, inadequate hand hygiene by healthcare workers and the close contact with other care givers and relatives (Kramer *et al.,* 2004). A number of viral respiratory infections can be identified easily by use of tests performed on upper respiratory secretions (Vayalumkal *et al.,* 2009).

There is little surveillance or consistently collected data on respiratory viral HAI in low and medium income countries. Prevention of respiratory viral HAIs in Kenya has the potential to save numerous lives each year. The study focused mainly on respiratory viral healthcare- associated infections.

1.2 Justification of the study

Respiratory infections represent the second most common cause of HAIs, globally (WHO., 2002). During the past years, there has been increasing interest in the control of HAI around the world (McDonald, 2006). The major emphasis, however, has been on bacterial infections, and the role of viruses as cause of HAI has not been well documented, especially so in developing countries (Dixon, 1978). In US 5% of all HAIs, were attributed to viruses (Valenti *et al.*, 1980).

In another study, 32% of HAIs in paediatric ward was attributed to viruses (Valenti *et al.*, 1980). Epidemic spread of certain viruses in healthcare setting has been documented in US (Saha *et al.*, 2009), and data on the burden of respiratory HAI in developing nation and more so in Kenya is scanty. Data on respiratory viral HAI in developing countries is scarce because insufficient funding is usually available for surveys and publication of such data (Faria *et al.*, 2007).

Lack of information on the number of patients with respiratory viral HAIs, at the health facilities, their mortality and the associated hospital costs, represents a challenge for hospital management. There are, however, some very basic measures that may be taken to reduce transmission in these setting (Darmstadt *et al.*, 2005). Measures to reduce the burden of HAIs, including respiratory infections, have been clearly articulated.

The available data on HAI focuses on bacterial infections, with incidence of 1.0/1000 days of blood stream infections (BSI) in the paediatric ward, which was 40 times higher than that of community acquired bacteria in the same region (Aiken *et al.*, 2011). Providing data on the magnitude of respiratory viral HAI can help inform clinicians and managers about the need for specific improvements in IPC practices.

Further, studies have shown that the act of feeding back HAI rate data to staff, even in the absence of specific IPC interventions, can considerably lower HAI rates (Haley, 1985; Gastmeier *et al.*, 2006).

This study sought to determine the incidence of respiratory viral HAIs in three hospitals, identify the pathogens associated with respiratory viral HAIs and examine the risk factors associated with respiratory viral HAIs in three hospitals in Kenya; Kenyatta National Hospital (KNH), Mbagathi District Hospital (MDH) and New Nyanza Provincial General Hospital (NNPGH).

1.3 Statement of the problem

Nasocomial infections are a major public health problem worldwide (Gikas *et al.*, 2004). Healthcare-associated infections constitute a major safety issue affecting the quality of care of hundreds of millions of patients every year in both developed and developing countries (Allegranzi *et al.*, 2007). Even in more highly resourced countries, preventing transmission of HAIs requires more than mandates, guidelines, or committees; successful programs rely on multifaceted approaches including education, marketing of key messages, data feedback, and explicit administrative support (Larson *et al.*, 2007).

Multifaceted Infection Prevention and Control (IPC) strategies-such as staff training, leadership, data feedback, and resource provision have been shown to reduce rates of HAI, making IPC an increasing priority in patient and (HCW) safety (Gastmeier *et al.*, 2006; Aboelela *et al.*, 2007). Improvement in IPC infrastructure is important to stop healthcare-associated transmission of emerging pathogens (such as avian or pandemic influenza and multidrug resistance tuberculosis) as well as endemic diseases such as Tuberculosis, human influenza, pneumonia, and gastroenteritis, among others.

These HAIs occur when microorganisms move from infected patients, healthcare workers (HCWs), or visitors to susceptible individuals, transmission can occur from patient-to-patient via healthcare worker hands or commonly touched services).

As part of establishing successful IPC infrastructure, the International Federation for Infection Control (IFIC) recommends HAI surveillance to raise awareness of transmission, detect outbreaks, identify problem areas, and help set priorities for infection control activity (Emori *et al.*, 1991; Ducel *et al.*, 2002; Michael Borg, 2011). Hospitals in Kenya are likely sites of transmission of infection between hospitalized patients as well as to healthcare personnel and community members.

In these hospitals, risk factors associated with infection transmission are common, including limited personnel and environmental hygiene practices, crowded conditions, limited staffing, improper waste handling and disposal, and a high proportion of patients with increased susceptibility, e.g., due to HIV, an increasingly elderly (Yokoe and Classen, 2008). Often, due to overcrowding, patients are cared for on floors, and sometimes patients share beds with one another.

In addition, friends and family members of patients sometimes provide care to patients and can be present 24 hours a day in some wards. The result is that large numbers of susceptible people are exposed to infectious diseases, including respiratory infections, through large droplets, fomites, including hands, and aerosols (Pittet and Donaldson, 2006; Tellier, 2006).

In Kenya, respiratory and diarrheal illnesses account for a substantial burden of morbidity and mortality (Nyandiko *et al.*, 2007). The pathogens that cause these conditions are readily transmissible in hospital settings, particularly in hospitals with inadequate infection prevention and control (IPC) infrastructure. Kenyan hospitals face ample challenges in controlling HAIs (MOH., 2010a). The country lacks dedicated resources and administrative support for infection control activities in hospitals. Many older hospitals face physical challenges such as lack of or inaccessible sinks. High patient volumes and short staffing combine to overwhelm even the most dedicated healthcare professionals (Gurley *et al.*, 2009).

Although the MoH has long mandated the establishment of infection control committees, these committees rarely meet and, for most hospitals, there is no standardized infection control training for healthcare personnel.

Respiratory viral HAI have been documented to cause substantial financial and healthcare burden in developed countries (Choi *et al.*, 2012; Polverino *et al.*, 2013). However, there is limited data from Africa, and particularly Kenya, that can indicate the extent of the problem and the aetiologies of these infections. Little is known about the respiratory microorganisms causing Respiratory HAIs circulating in Kenya**.** Documenting the magnitude of the respiratory HAI in these facilities is essential to help plan the prevention strategies. Prevention of respiratory HAI in Kenya has the potential to save numerous lives each year.

1.4 Research question(s)

1. What is the incidence of respiratory viral HAIs amongst inpatients in selected Kenyan hospitals?
2. What are the risk factors for respiratory viral HAI amongst the inpatients in selected hospitals in Kenya?

1.5 Study objectives

1.5.1 General objective

To describe respiratory viral healthcare- associated infections amongst inpatients in three selected hospitals (KNH, MDH and NNPGH) in Kenya

1.5.2 Specific objectives

1. To establish the incidence of respiratory viral HAIs among patients admitted in selected hospitals in Kenya
2. To identify the pathogens associated with respiratory viral HAIs in the selected hospitals
3. To determine the risk factors for respiratory viral HAIs amongst inpatients in KNH, MDH and NNPGH hospitals.

CHAPTER TWO

LITERATURE REVIEW

2.1 Healthcare associated infections (HAI)

Healthcare associated infections (HAI), originally referred to those infections associated with admission in an acute care hospital (formerly called nosocomial infections), but the term now applies to infections acquired in the continuum of settings where persons receive healthcare for example long term care, home care, ambulatory care and acute care (Collins, 2008). This also includes occupational infections among staff of the facility (Benenson, 1995; Uneke and Ijeoma, 2010). In 2004, Centers for Disease Control and prevention (CDC) developed baseline definitions for HAIs (Horan *et al.*, 2008). HAIs were defined as an infection that develops in a patient 48 to 72 hours or more after admission to a hospital and within 10 days after hospital discharge (Ducel *et al.*, 2002) or within 48 hours after insertion of an indwelling device, such as a urinary catheter.

Infections that occur within the first 48 hours of hospitalization are considered to have been picked up in the community, and are referred to as community-acquired infections. The 48 hour cut-off is somewhat arbitrary as infections have variable incubation periods (Edwards *et al.*, 2008).

2.2 The burden of HAI

Healthcare associated infection (HAI) is a major health problem in both developed and developing countries (Pittet, 2005b), leading to substantial morbidity and mortality worldwide. The occurrence of HAI is a threat to the health and safety of both patients and health care workers (HCW).The HAI infection rates are considered as an indicator of the quality of health care and also the appropriateness of Infection control measures (Lazzari, 2004).

Healthcare associated infections are adverse patient events that affect approximately 2 million persons annually (Burke, 2003; Edwards *et al.*, 2008) , almost 100,000 deaths and $4.5-6.5 billion in additional healthcare spending in USA (Starfield, 2000; Klevens *et al.*, 2007; Stone, 2009).

In England 100,000 cases of HAI are estimated to cost the National Health Service a minimum of £1 billion per year with more than 5,000 attributable deaths annually (Mayor, 2000). These infections are associated with increased morbidity and mortality as well as increased length of stay and costs of care (Danchaivijitrmd *et al.*, 2005). About 5% of the world populations (around 300 million people) are hospitalized every year. If 5% of them suffered from a HAI, there would be 15 million hospitalized patients. Considering an average attributable mortality rate of 10%, 1.5 million of them would die of HAI (Boyce *et al.*, 1994). The most frequent HAIs are infections of surgical wounds, urinary tract infections and lower respiratory tract infections (Ducel *et al.*, 2002; Bagheri Nejad *et al.*, 2011).

Findings from a study done in 2011, by WHO showed that the highest prevalence of 50% HAIs occurs in ICU (Allegranzi *et al.*, 2011), acute surgical and orthopaedic wards (Dixon, 1978; Michael Borg, 2011). Infection rates are higher among patients with increased susceptibility because of old age, underlying disease, or chemotherapy (Ducel *et al.*, 2002).

The impact of HAIs is more severe in resource-poor settings, where the rate of infection is estimated to range from 25 to 40% (WHO., 2005; Uneke *et al.*, 2010). Healthcare associated infections have been reported to exact a tremendous toll on patients, families and systems of care, resulting in increased morbidity and mortality and increased healthcare costs. Major international health organizations have advocated the urgent need for research to assess the burden and implications of HAI in developing and transitional countries (WHO., 2007).

A number of infections can be transmitted or acquired by the patient while receiving care in a health facility, these includes, respiratory infections, urinary tract infections, surgical site infects among others (Collins, 2008). Patient care is provided in facilities which range from highly equipped clinics and technologically advanced university hospitals to front-line units with only basic facilities. Despite progress in public health and hospital care, infections continue to develop in hospitalized patients, and may also affect hospital staff.

Many factors promote infection among hospitalized patients: decreased immunity among patients; the increasing variety of medical procedures and invasive techniques creating potential routes of infection; and the transmission of drug-resistant bacteria among crowded hospital populations, where poor infection control practices may facilitate transmission. There is little surveillance or consistently collected data on HAI in developing countries, but scant data suggests that in resource-poor settings, HAIs occur for 10-30% of all admissions (Pittet and Donaldson, 2005a, 2005b).

2.3 The aetiology of Healthcare associated infections (HAI)

Transmission of infectious agents within a healthcare setting requires three elements: an infectious agent, a susceptible host with a portal of entry receptive to the agent, and a mode of transmission for the agent. Organisms causing respiratory HAI may originate from the host's endogenous flora, other patients, visitors, hospital staff or environmental sources. Some organisms may be acquired from an inanimate object or substances recently contaminated from another human source referred to as environmental infection (Raka, 2010). Contact between the patient and microorganism does not by itself necessarily result in the development of clinical disease; other factors influence the nature and frequency of nosocomial infections. The likelihood of exposure leading to infection depends partly on the characteristics of the microorganisms, including resistance to antimicrobial agents, intrinsic virulence, and amount (inoculum) of infective material.

Before the introduction of basic hygienic practices and antibiotics into medical practice, most hospital infections were due to pathogens of external origin (food borne and airborne diseases, gas gangrene, tetanus or were caused by microorganisms not present in the normal flora of the patients (diphtheria, tuberculosis).

Progress in the antibiotic treatment of bacterial infections has considerably reduced mortality from many infectious diseases. Most infections acquired in hospital today are caused by microorganisms like *Staphylococcus aureus*, coagulase-negative *staphylococci*, *enterococci*, *Enterobacteriaceae* which are common in the general population, in whom they cause no or milder disease than among hospital patients (Lyytikainen, 2002).

2.4 Patient susceptibility to healthcare-associated infections

Important patient factors influencing acquisition of infection include age, immune status, underlying disease, and diagnostic and therapeutic interventions. The extremes of life, infancy and old age are associated with a decreased resistance to infection. Patients with chronic disease such as malignant tumours (Kamboj and Sepkowitz, 2009; Cornejo-Juarez *et al.*, 2015), leukaemia, diabetes mellitus, renal failure, or the acquired immunodeficiency syndrome (AIDS) have an increased susceptibility to infections with opportunistic pathogens. The latter are infections with organism (s) that are normally innocuous, such as part of the normal bacterial flora in the human, but may become pathogenic when the body's immunological defenses are compromised. Immunosuppressive drugs or irradiation may lower resistance to infection injuries to skin or mucous membranes bypass natural defence mechanisms (Gurley *et al.*, 2010), including malnutrition.

Many modern diagnostic and therapeutic procedures, such as biopsies, endoscopic examinations, catheterization, intubation/ventilation and suction and surgical procedures increase the risk of infection.

Contaminated objects or substances may be introduced directly into tissues or normally sterile sites such as the urinary tract and the lower respiratory tract (Rosenthal *et al.*, 2014).

2.5 Environmental factors associated with HAI

Healthcare settings are an environment where both infected persons and persons at increased risk of infection come together. Patients with infections or carriers of pathogenic microorganisms admitted to hospital are possible sources of infection for patients and staff. Patients who become infected in the hospital are a further source of infection. Crowded conditions within the hospital (Gurley *et al.*, 2010; Bagheri Nejad *et al.*, 2011), frequent transfers of patients from one unit to another, and concentration of patients highly susceptible to infection in one area (new-born infants, burn patients, and intensive care) all contribute to the development of nosocomial infections. Microbial flora may contaminate objects, devices, and materials which subsequently contact susceptible body sites of patients. In addition, new infections associated with bacteria such as waterborne bacteria (atypical mycobacterium) and/or viruses and parasites continue to be identified (Archibald and Jarvis, 2011).

2.6 Global impact of HAI

Healthcare-associated infections are increasingly becoming common worldwide (Haley, R. W. *et al.*, 1985), due to an increase in invasive procedures and a growing resistance to antibiotics (Schwegman, 2008). The healthcare associated infections have increased by 36% in the last 20 years. The burden of HAIs can be divided into: the cost of quality, the cost of human lives and the financial impact (Schwegman, 2008; Mauldin *et al.*, 2010). The impact of HAIs is more severe in resource-poor settings, where the rate of infection is estimated to range from 25% to 40% (WHO., 2005).

Healthcare-associated infection add to functional disability and emotional stress of the patient and may, lead to disabling conditions that reduce the quality of life (Pittet, Allegranzi, *et al.*, 2005).

HAIs are also one of the leading causes of death (Ponce-de-Leon, 1991; Pittet, Allegranzi, *et al.*, 2005). The economic costs are considerable (Wenzel, 1995; Plowman, 2000). The increased length of hospitalisation for infected patients is the greatest contributor to cost (Wakefield *et al.*, 1988; Pittet *et al.*, 1994; Kirkl *et al.*, 1999) with average hospital stay between 7.4 and 9.4 days (Schwegman, 2008).

The cost vary from country to country, for example, in Trinidad and Tobago HAI represent 5% of the annual ministry of health budget, In Thailand some hospitals spend 10% annually and in Mexico, 70% of the health ministry budget is spent on HAIs (WHO., 2007). Prolonged stay not only increases direct costs to patients but also indirect costs due to lost work (Klevens *et al.*, 2007). The increased use of drugs, the need for isolation, and the use of additional laboratory and other diagnostic studies also contribute to costs (Nettleman, 1993). Healthcare-associated infections add to the imbalance between resource allocation for primary and secondary health care by diverting scarce funds to the management of potentially preventable conditions (Nettleman, 1993).

The advancing age of patients admitted to health care settings, the greater prevalence of chronic diseases among admitted patients, and the increased use of diagnostic and therapeutic procedures which affect the host defences will provide continuing pressure on nosocomial infections in the future (Strausbaugh, 2001). Organisms causing Healthcare associated infections can be transmitted to the community through discharged patients, staff, and visitors (Uneke *et al.*, 2010). This spread may be particularly important during outbreaks, and health-care settings can act as multipliers of disease, with an impact on both hospital and community health. During the Marburg Viral Haemorrhagic outbreak in Angola, transmission within the healthcare facility played a major part in the amplification of the outbreak (WHO., 2005). If organisms are multi-resistant, they may cause significant disease in the community.

2.7 Respiratory viral healthcare associated infections

Respiratory tract infections (RTI) are among the most common infectious diseases of humans' worldwide, causing significant morbidity and mortality (Kate, 2007), largely because of high attack rate (Fendrick *et al.*, 2003). In developing countries, morbidity due to RTI may be at least as severe as that in industrialized countries; for children younger than 5 years, these infections are the leading cause of death (Denny, 1995). Respiratory infections represents the second most common cause of HAI (Allegranzi *et al.*, 2011). Respiratory viral HAIs are infections of the respiratory system contracted during a hospital stay. This type of infection tends to be more serious, because patients in the hospital already have weakened defence mechanism, and the infecting organism are usually more dangerous than those encountered in the community.

The infection can be due to viral, bacterial or fungal pathogens. Infectious agents like viral, bacterial, and fungal pathogens causing respiratory viral HAI may come from endogenous or exogenous sources. Endogenous sources include body sites normally inhabited by microorganisms, for examples nasopharynx. Exogenous sources include those that are not part of the patient. Examples include visitors, medical personnel, other patients' equipment and the healthcare environment (Islam *et al.*, 2014). Patient-related risk factors for invasion of colonizing pathogen include severity of illness, underlying immunocompromised state and/or the length of in-patient stay.

This study focuses on the viral pathogens as the cause respiratory viral HAI. The outcome of infection is generally good, although life threatening illness can occur, usually for unknown reasons, even in the immunocompetent (Carman and Mahony, 2007). They are transmitted either from contact (skin to skin or fomites) or via airborne particles. Healthy people can usually fight off viral infections. However, people who are sick have a weakened immune system (Couch *et al.*, 1997).

2.7.1 Etiology and pathophysiology of viral respiratory HAI

Respiratory viral HAI constitute a major cause of upper and lower respiratory infections.

Viruses are the causal pathogen in most upper respiratory tract infections, with fewer than 10% of the cases caused by bacteria. The following are common viral pathogens implicated in RTI: rhinoviruses and enteroviruses, influenza, parainfluenza virus (PIV), respiratory syncytial viruses (RSV), Adenovirus, Coronaviruses and Human metapneumovirus (HMPV) in the winter (Monto *et al.*, 1987; Fahey *et al.*, 1998). These viruses are the leading causes of respiratory HAI, especially in the paediatric populations (Thompson *et al.*, 2003). Overcrowded hospital wards and understaffed health services increase the risk of Respiratory viral HAI in the process of care (Clements *et al.*, 2008).

A quote from the world Health Report 1996- fighting disease, fostering development, helps to underscore the importance of HAI, *"*Hospitals are intended to heal the sick, but they are also sources of infection. Ironically, advances in medicine are partly responsible for the fact that, today, hospital infections are a leading cause of death in some parts of the world.**"**

2.7.1.1 Respiratory syncytial virus (RSV)

Respiratory syncytial virus (RSV) has been recognized as one of the major cause of respiratory illness (bronchiolitis, or viral pneumonia) in all ages worldwide (Langley and Anderson, 2011). Several reports have described clinical and pathological aspects of HAIs with respiratory syncytial Virus (Ditchburn *et al.*, 1971; Hall, 1977). In adults, RSV tends to cause mild cold symptoms; in school-aged children, it can cause a cold and bronchial cough; in infants and toddlers it can cause bronchiolitis or pneumonia (Templeton, 2007). Respiratory syncytial virus is a major cause of morbidity in infants and young children (Levin, 1994) and has been reported to be approximately 45% of all admissions for acute respiratory diseases in those under the age of 2 years (Hall, 1977).

About 70% of infants are infected with RSV during the first year of life, and most children have been infected at least once by the age of three (Garcia *et al.*, 1997). Recurrences may occur in older children or adults, since the immunity is short lasting (Garcia *et al.*, 1997).

The virus is spread by direct inhalation of large droplets and by direct contact. The infected individuals shed large amount of viruses in their respiratory secretions usually for about 7 days with a range of 1-21 days (Hall, 1977; Goldwater and Martin, 1991); via un-gloved or unwashed hands of the healthcare worker or relative of the patient or through contamination of the environment by coughing or sneezing (Aitken and Jeffries, 2001).

Respiratory syncytial virus can persist on skin or porous surfaces such as gown or tissue paper for up to 30 minutes and up to 6 hours on non-porous surfaces like gloves (Hall *et al.*, 1980). Transmission of RSV in health-care settings usually occurs during yearly community outbreaks of infection and is associated with marked increases in hospitalizations and deaths from pneumonia and bronchiolitis in young children *(Brandt et al., 1973; Anderson et al., 1990; Leader and Kohlhase, 2002).*

In USA, a study done by Hall *et al (2000),* reveal that respiratory HAI cross infection in paediatric wards occurred in 40% of the patient hospitalized for more than 7 days (Hall, 2000). The risk factors for respiratory HAI due to RSV include; community outbreaks of RSV infection, visitors and personnel infected with RSV visiting patients in the hospital *(Hall, 1983, 2000),* and health-care personnel, *(Hall et al., 1975; Hall, 1981; Islam et al., 2014)*. Patients with suppressed immune systems can remain infectious for prolonged periods of time and be positive for RSV intermittently (Falsey *et al.*, 1995; Han *et al.*, 1999).

Infected infants, however, are probably the most effective sources of RSV because they shed high titres of the virus for prolonged periods and require very frequent close contact with their care givers, and therefore, present a greater chance of contaminating other persons or their environment with infectious respiratory secretions (Hall *et al.*, 1976).

In one outbreak in Toronto, Canada, three distinct sources of RSV with transmission of each strain within the ward were identified resulting in death of the eight patients (Mazzulli *et al.*, 1999). In 2012, Camila *et al* documented an outbreak of RSV in a neonatal intensive care unit (NICU) in Sao Paulo, Brazil which led to ten infants being infected before the situation was brought under(Silva Cde *et al.*, 2012).

In another outbreak of RSV in USA, Halasa *et al* (2005) documented that the outbreak costed the hospital over $1.15 million (US dollars), a cost the attending physician felt could have been significantly reduced had RSV been diagnosed as soon as symptoms began to develop. This facility now recommends that all infants in NICU who develop cough, congestion or apnoea should be tested for RSV and other common respiratory viruses during the winter season (Halasa *et al.*, 2005) .

Laboratory methods available to diagnose RSV and other viral respiratory infections include traditional tissue culture, shell-vial tissue culture, antigen detection assays, PCR assays, and serologic assays. The optimal method for diagnosing infection varies with the patient's age (Parrott *et al.*, 1973; Falsey and Walsh, 1992; Wright, 1993) . The most important aspect of prevention/control of RSV HAI is isolation, cohorting of infected patients and cohorting of staff to infected patients since use of masks and gowns by staff has been reported not to reduce RSV HAI (Hall and Douglas, 1981; Goldwater, Martin, *et al.*, 1991).

2.7.1.2 Adenovirus

Human adenoviruses (HAdVs) are non-enveloped viruses belonging to the genus Mastadenovirus of the *Adenoviridae* family. Human adenoviruses (HAdVs) are classified by species (A–G), serotype (1–52) (Jones *et al.*, 2007; Henquell *et al.*, 2009; McCarthy *et al.*, 2009), on the basis of hemagglutination and oncogenic and DNA homology properties. Adenovirus was first isolated in 1953 by investigators trying to establish cell-lines from adenoidal tissue of children removed during tonsillectomy and from military recruits with febrile illness (Stewart *et al.*, 1993). In 1962, some Adenoviruses were shown to cause tumours in rodents - this caused a considerable panic.

Adenovirus oncogenesis appears to be associated with abortive infections and has never been observed in humans (Russell, 2009; Anon, 2011). Members of the adenovirus family (*Adenoviridae*) infect a great variety of post-mitotic cells, even those associated with highly differentiated tissues such as skeletal muscle, lung, brain and heart. Since they deliver their genome to the nucleus and can replicate with high efficiency, they are prime candidates for the expression and delivery of therapeutic genes.

They have a wide host-range and are currently divided into three genera with further subdivision into species (also termed subgenera or subgroups) A to F. Division of human serotypes, based mainly on immunological criteria, has historically been the basis of classification (Mautner *et al.*, 1989; Lukashok and Horwitz, 1998).

Adenovirus viruses are the frequent cause of self-limiting infections, mostly asymptomatic (Fox *et al.*, 1969). People infected by the adenovirus may shed the virus for months or even years (Wright, 1993). Mild clinical manifestations include conjunctivitis (Percivalle *et al.*, 2003), upper and lower respiratory diseases gastroenteritis and haemorrhagic cystitis (Fox *et al.*, 1969; Larsen *et al.*, 1986).

In contrast, HAdVs can cause life-threatening disseminated infection in neonates, severe immunocompromised patients such as bone marrow transplant recipients, and in patients with chronic heart or lung disease.

Adenovirus 7h Respiratory HAI outbreaks with high secondary attack and lethality rates emerged in Chile during the 1990s (Palomino *et al.*, 2000; Hatherill *et al.*, 2004). The occurrence of severe community epidemics and Healthcare associated outbreaks suggests the emergence of virulent adenovirus strains. Certain serotypes, especially 3 and 7, have been associated with severe adenoviral pneumonias in infants' worldwide (Larranaga *et al.*, 2007).

Infection may be introduced from the community into a hospital setting via staff, patients, or visitors. Transmission of the virus can be by droplets (Sanchez *et al.*, 1997), aerosols, faecal-oral route and contaminated environment (Mueller and Klauss, 1993; Wright, 1993). Because adenovirus is a non-enveloped virus, it is not inactivated by detergents but can be inactivated by 70%-alcohol (Craven *et al.*, 1987).

2.7.1.3 Human Parainfluenza Viruses (HPIVs)

Human Parainfluenza Viruses (HPIVs) are single stranded RNA viruses belonging to the paramyxovirus family. There are four types of parainfluenza viruses, 1-4 with type 1, 2 and 3 being the most important. They are the major cause of laryngotracheobronchitis (croup) in children and also responsible for upper respiratory tract infection (Type 1, 2 and 3) and bronchiolitis (type 3) (Aitken *et al.*, 2001) virtually all children have been infected with parainfluenza type 3 by the age of 2 years with infections due to type 1 and 2 occurring at a lower rate. In the U.S, 74% and 54% of children have been infected with type 1 and type 2 respectively, by the age of 5 years.

Most infections are self-limiting in the immunocompetent hosts but can be severe in immunocompromized hosts (Aitken *et al.*, 2001; Harvala *et al.*, 2012).

Whereas type 1 and 2 HPIVs are often community acquired, Type 3 is the most common serotype causing respiratory HAIs in immunocompromised hosts (Aitken *et al.*, 2001).

Respiratory HAIs transmission of type 3 has also been reported in neonatal units and homes of the elderly (Moisiuk *et al.*, 1998; Harvala *et al.*, 2012).Evidence suggests that outbreaks are more likely to be due to transmission between patients rather than the reintroduction of different strains by staff or visitors (Karron *et al.*, 1993; Aitken *et al.*, 2001). HPIVS are transmitted by direct or indirect contact with infected respiratory secretions. The viruses can survive for up to 10 hours on non-absorptive surfaces and 4 hours on absorptive surfaces like lab coats and gowns (Brady *et al.*, 1990).

2.7.1.4 Human metapneumovirus (HMPV)

Human metapneumovirus (HMPV) was first described in 2001(van den Hoogen *et al.*, 2001) and is a significant respiratory pathogen (Don *et al.*, 2008; Albuquerque *et al.*, 2009; Nascimento-Carvalho *et al.*, 2011b). The HMPV causes respiratory disease similar to that caused by RSV (Kahn, 2003). The virus was isolated as the sole pathogen in 2.4% of children with respiratory HAI in Brazil (Nascimento-Carvalho *et al.*, 2011a)

2.7.2 Epidemiology of respiratory viral HAI

Respiratory viral HAI due to viral causes are estimated to occur in 1% of all hospitalizations (Dixon, 1978; Valenti *et al.*, 1980). Valenti *et al.* (1980) in a university hospital with approximately 23000 admissions per year showed 5.3% of 1164 total HAI had respiratory viral HAI. Goldwater *et al,* (1991) in Adelaide children's hospital, showed 46% of 601 patients were positive for one or more viruses.

Both developed and resource-poor countries are faced with the burden of Respiratory viral HAI. Respiratory viral HAI leads to increased length of stay, mortality and increased healthcare costs (Gurley *et al.*, 2010). Valenti *et al.* (1980) documented patients with Respiratory viral HAI had a mean increase in hospital stay of at least 9.3 days compared with uninfected controls. Respiratory viral HAI do not have a discernible sex predilection, though infection with some specific viruses seems to have some sex predilection. For example, the frequency of hospitalization for respiratory syncytial virus (RSV) is higher in males, with a male-female ratio of approximately 2:1 (Valenti *et al.*, 1980; Hall *et al.*, 2013; Pineros *et al.*, 2013). Respiratory viral HAI occur in both adult and children, with children being the most affected.

Respiratory HAI remains a major concern globally as it accounts for 15% of HAIs (Allegranzi *et al.*, 2011). Data from low income countries shows that 6.5-33% of patients with HAIs, with respiratory infections leading (Orrett *et al.*, 1998; Danchaivijitr *et al.*, 2007). In Germany, a study done by Kampf *et al* (1997) showed that of the 543 HAIs, 107(19.7%) were Respiratory HAIs (Kampf *et al.*, 1997). A surveillance study in Bangladesh tertiary care hospitals reported 1.7 % of respiratory HAIs, of all patient hospital admissions (Gurley *et al.*, 2010).

In Sub-Saharan Africa, 6.8% of the obstetric and gynecological patients investigated in Addis Ababa were found to have respiratory HAIs (Gedebou *et al.*, 1988; Gosling *et al.*, 2003). In Tanzania, in a study conducted in a tertiary referral hospital, Respiratory HAI accounted for 9.8% of all types of HAIs (Gosling *et al.*, 2003).

In a study, conducted in Algeria university hospital from 2001 to 2005, showed hospital acquired pneumonia was 1.7% (Atif *et al.*, 2006) and in a similar study in Senegal, the prevalence of hospital acquired pneumonia was 2.9% (Dia *et al.*, 2008) and in another study in ICU, the proportion of patients with respiratory HAI was 50% (Diouf *et al.*, 2006).

In a study to show the reduction of hospital acquired pneumonia using surveillance system in a neonatal intensive care unit (NICU) in Algeria, documented cumulative incidence of respiratory HAI to be 2.4% (Atif *et al.*, 2009).

The World Health Organization has acknowledged preventing hospital associated infections in lower income countries a priority (Pittet *et al.*, 2008). There is little evidence to show which interventions work best in these countries, to prevent such infections. There are few published data about the burden of respira tory HAIs in low income countries like Kenya. This is because HAI diagnosis is a complex and surveillance activities to guide interventions require expertise and resources.

Surveillance systems are in some developed countries and offer systematic reports on national trends of endemic HAI (Pittet, Allegranzi, *et al.*, 2005) , such as the National Healthcare Safety Network (NHSN) of the United States of America or the German hospital infection surveillance system. This is not the situation in most developing countries (Marcel *et al.*, 2008; Organization, 2010) because of social and health-care system deficiencies that are aggravated by economic problems.

2.7.3 Factors influencing the development of respiratory viral HAI

Generally, risk factors for HAIs include those associated with treatment plans, health care workers behaviors and those associated with devices such as mechanical ventilators that disrupt normal host protection mechanisms such as intact mucosal membranes (Sydnor *et al.*, 2011). Paediatric and adult patients share common risk factors for respiratory viral HAIs. Patients undergoing specialized respiratory care are at high risk of acquiring Respiratory Viral HAI, although it is difficult to separate the contribution of respiratory care from that of intrinsic host susceptibility. Respiratory care may predispose the patient to Respiratory viral HAI.

For example, tracheostomy or intubation, injure the mucosa and reduce its resistance to infection; other procedures to which such patients are often exposed, such as bronchoscopy may increase the risk of infection (Dixon, 1983).

There are, however, additional factors inherent to children. When young children encounter common pathogens such as RSV, it is often their first encounter. This immunological naivety not only affects the likelihood of infection but it can also affect the severity of infection and duration of microorganism shedding (Posfay-Barbe, 2008) The immune system of the infant, especially the premature infant, has limitations of both innate and adaptive immunity. Finally, normal child development, in terms of behavioral and emotional needs, affects the risk of infection (Posfay-Barbe, 2008).

Viral infections in children, are mostly under-reported because of the fact that appropriate tests are not done and infections are poorly identified or not identified at all (Frota *et al.*, 2002; Posfay-Barbe, 2008). Viral infections cause substantial morbidity and mortality, among the premature infants and children with chronic medical conditions, like congestive cardiac failure.

Intensive care unit (ICU) exposure is also recognized as a major risk factor for respiratory HAI (Dixon, 1983). This is because patients in ICU are likely to be in many medical devices like endotracheal intubation, which is one of the most commonly performed procedures in the ICU. Respiratory viral HAIs outbreaks have been reported in the new born intensive care units (Maltezou and Drancourt, 2003; Faden *et al.*, 2005). Attack rates of 35% have been reported (Singh-Naz *et al.*, 1990; Posfay-Barbe, 2008). Adenovirus can cause a high mortality rate of about 28% during an outbreak (Posfay-Barbe, 2008). Respiratory syncytial virus has been reported to cause a mortality of about 13% among children with other medical conditions (Madhi *et al.*, 2004; Posfay-Barbe, 2008).

2.7.4 Prevention of respiratory Healthcare associated infections (HAI)

Respiratory viral infections are easily transmitted in closed environments. Copious amounts of respiratory secretions increase the chance of infection spread, with children often producing the greatest volumes (Aitken *et al.*, 2001). The knowledge of which virus or viruses is/are present and who has had close contact may guide use of antiviral agents for prophylaxis or vaccination.

The known approaches to control respiratory HAIs include: 1) efforts to eradicate infecting microorganisms from their epidemiologically important environments; 2) steps to interrupt transmission of organisms from person to person; and 3) attempts to alter host susceptibility. The first two are important for any hospital infection control program. To discourage patient infection, a high level of cleanliness of respiratory devices and other reservoirs needs to be maintained (WHO., 2002; Allen and Griffith, 2005; Collins, 2008).

A lot has been done to alter host susceptibility especially in research for viral and bacterial vaccines, nutritional supplementation to improve host resistance and immune stimulation. In addition, a change in the approach to antimicrobial management of patients might also improve host susceptibility. The optimal approach to minimizing antibiotic resistant organisms in the hospital includes: 1) limit the introduction of antibiotic-resistant organisms into the hospital. This is most difficult to accomplish. Control can only be achieved by proper initial treatment of infections; eradication of carriage, whenever possible; and the proper isolation of patients who may bear these organisms, as quickly as possible on their admission to the hospital; 2) minimize the use of antibiotics, in an attempt to limit the emergence of antibiotic-resistant strains (Wenzel, 2000).

In addition, to the approaches above, a substantial proportion of respiratory HAI can be prevented by infection control programs that emphasize surveillance of respiratory HAI, other HAIs and staff education.

It has been shown that hospitals with effective infection surveillance and control programs had pneumonia rates approximately 20% lower than hospitals without such programs (Haley, 1985; Jarvis *et al.*, 1985; Sydnor and Perl, 2011).

If patients with respiratory viral infections are not diagnosed on hospital admission, HAIs may occur (Serwint and Miller, 1993). Surveillance appeared to be a potent independent factor associated with a reduced incidence of respiratory HAI in the Study on the Efficacy of Nosocomial Infection Control (SENIC) study (Haley, R. W. *et al.,* 1985). These studies suggest that there is great potential for prevention of respiratory HAI. They also give us hope that more of these HAIs can be prevented.

2.7.4.1 Hand Hygiene

Hand hygiene is the most effective measure to prevent cross-transmission of microorganisms (Pittet *et al.*, 2006; Al-Wazzan *et al.*, 2011). Adequate hand hygiene can be achieved by standard hand washing—with water alone or with soap—or by the use of an alcohol based hand-rub solution. Despite considerable efforts, compliance with this simple infection-control measure remains low.

Factors predicting non-compliance have been extensively studied, and include physician status (Hugonnet and Pittet, 2000), procedures associated with a high risk of cross-transmission, and workload. Future interventions to improve compliance should consider complex behavioral theories and the use of multimodal and multidisciplinary strategies. One of the key components of these interventions should be the wide use of alcohol based hand-rub, which is microbiologically effective and less time-consuming than standard hand washing (Rotter *et al.*, 2005).

Although some of the interventions to reduce nosocomial pneumonia are the responsibility of physicians or other health care workers, many of the interventions are the direct responsibility of nurses or can be influenced by nurses (Ruth, 2008).

Nursing care can directly contribute to prevention of hospital-associated pneumonia, particularly in patients who are most at risk due to advanced age, postoperative status, or mechanical ventilation. The evidence shows that the most important contributions of nursing care to prevention of hospital-associated pneumonia are in four areas: hand hygiene, respiratory care, patient positioning, and education of staff (Pittet, 2005a). Hand hygiene is an essential component of hospital-associated pneumonia reduction. Evidence-based guidelines have been published for general hand hygiene as well as specific hand hygiene measures related to respiratory care.

Evidence exists that alcohol hand rubs effectively reduce the transmission of potential pathogens from health care workers' hands to patients. For hands that are not visibly soiled, alcohol hand rubs are more effective than hand washing with plain or antimicrobial soap (WHO., 2002; Boyce, 2013). In the health care setting, the preferred method for cleaning visibly soiled hands is washing with water and antimicrobial soap. Gloves should be worn for handling respiratory secretions or any objects contaminated with respiratory secretions. If soiling from respiratory secretions is anticipated, a gown should also be worn. Hand decontamination and glove changes are required between contacts with different patients, as well as in an encounter with a single patient between contacts with a contaminated body site and the respiratory tract or respiratory equipment (Samuel *et al.*, 2005; WHO., 2007).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area

The study was carried out in New Nyanza Provincial General Hospital (NNPGH), located in Nyanza province, Kenyatta National Hospital (KNH) and Mbagathi District Hospitals (MDH) located in Nairobi provinces (Figure 3.1). The hospitals selected are not representative of all Kenyan hospitals and healthcare facilities, but collectively represent a broad cross-section in terms of size and case mix in Kenya. The two hospitals in Nairobi (KNH and MDH) and one in Kisumu (NNPGH) were selected in part for geographic convenience; more oversight and support of the laboratory capability to transport and test the viral specimens. In addition, the three hospitals were chosen on the basis of their previous research relationship with Kenya medical research institute (KEMRI) and centres for disease control (CDC-Kenya), and interest by the hospital administrators in participating in the study.

The Hospital infection control committee were recently activated and adopted the national infection control policy and guidelines, which endorses performance of HAI surveillance as outlined here as part of normal hospital activity. Thus, this respiratory HAI surveillance would provide results with useful generalizability to other government hospitals.

3.1.1 New Nyanza Provincial General Hospital (NPGH)

This is a regional referral hospital located in Kisumu with 459 inpatient beds, with 18000 admissions and 194,000 outpatient visits annually (MOH., 2010b). Hospital-wide, average length of stay is 7.2 days. NNPGH acts a referral centre for many facilities within its catchment area of western Kenya (Figure 3.1)

3.1.2 Kenyatta National Hospital (KNH)

This is the largest hospital in Kenya, located in Nairobi. As a national referral hospital, it receives referrals from the entire country for specialized care and treats a large number of paediatric and adult patients from the Nairobi region. KNH has 1800 beds (with 2000-2500 patients admitted at any given time), with 89,000 admissions and 600,000 outpatient visits annually. Hospital-wide, average length of stay is seven days. KNH is the national referral centre for many facilities in Kenya and the region of East Africa (Figure 3.1)

3.1.3 Mbagathi District Hospital

This hospital, located in Nairobi, with 200 inpatient beds, no ICU or burns wards, with 5000 admissions and 222,350 outpatient visits annually. Hospital-wide, average length of stay is 7.0 days. The hospital was built in the 1950's, initially, it was established to treat patients with infectious disease (tuberculosis, meningitis, and leprosy), but now provides a broad range of services for the largely poor population of the Kibera slums in Nairobi-one of the largest informal settlement in Africa.

MDH acts a referral centre for several small facilities within its catchment area, and also refers a limited number to KNH for further investigation and treatment (Figure 3.1)

Figure 3.1: Map showing the location of the study sites

3.2 Study design

This was an observational prospective study carried out at three Kenyan hospitals between September 2009 and July 2010. The study was done in three selected hospitals in Kenya, representing, three different categories (Level 6, 5, and 4) and in different regions (Western and Nairobi) of Kenya.

3.3 Target population

The target population comprised of inpatients of any sex or age admitted at the participating hospitals, and are in the selected wards. The selected hospitals included; Kenyatta National Hospital (KNH), New Nyanza Provincial General Hospital (NPGH), and Mbagathi District Hospital (MDH), (Figure 3.1). For each hospital, one paediatrics, one medical, and surgical ward were selected for study. In addition, at KNH and NPGH, specialty wards were included as patients on these wards are likely to have high rates of HAI due to length of hospitalization and intensity of care.

3.3.1 Inclusion criteria

a. Admitted patient and has been on the ward for more than 72 hours (more than or equal to 3 calendar days)
b. Experiences new onset of temperature greater than or equal to 38.0°C or hypothermia of <35.0°C and
c. Has either cough or sore throat and clinical features of new respiratory infection
d. Patients consents to participate in the study

3.3.2 Exclusion criteria

a. Patients admitted in other wards other than the study wards
b. Patients who do not consent to participate in the study
c. Patients who are admitted in the study wards with fever
d. Patients admitted with cough or sore throat or clinical features of respiratory infection
e. Patients who were in hospital for less than 72 hours

3.4 Sample size determination

All patients admitted in the selected wards of the participating hospitals meeting the HAI criteria between September 2009 and July 2010 were recruited into the study. The determination of the minimum sample size was determined using Fischer's formula for sample size determination, 45.8% incidence was used from Kesah *et al* (2004)carried out in Nigeria.

$$n = \frac{Z^2 pq}{d^2}$$

n= the desired sample size

z= standard normal deviate set at 1.96 which corresponds to 95% confidence level.

P= proportion in the target population estimated to have the characteristic being measured (45.8% incidence rate of HAI in Nigeria)

Q= 1.0-p

D= desired width of 95% confidence interval or degree of accuracy at 0.05

The minimum sample size of 382 patients was obtained.

Because of follow up it was modified by addition of 10% of the total. This gave a minimum sample size of 421 patients.

3.5 Surveillance of respiratory HAI

Data collection was from 1st September 2009 through 31st July 2010. All patients admitted to selected wards during the study period and met the inclusion criteria were considered eligible until they left the ward (even if they were discharged but remained on the ward).

A daily line-list (Appendix 1) was compiled for patients meeting the clinical criteria for HAIs (case definitions). When a patient who met the criteria for HAI based on timing of symptom onset (Figure 3.2), was identified, HAI Report Form (Appendix 2) was filled. The form captured information extracted from patients' charts, including laboratory reports, X-ray reports that reviewed twice a week, to identify patients hospitalized for more than 72 hours who developed new onset of documented fever, cough, sore throat, cracles, rhonchi, decreased breath sounds, or crepitus.

In addition, patient's age, sex, admitting diagnosis, date of admission, dates of new onset of symptoms, history of previous hospitalization, if he had relatives and or friends visiting and the duration they stayed with the patient and date and outcome of hospitalization (i.e. the patient was discharged, was referred, or died) were captured. Research assistants kept track of patients with suspected HAI on a separate line list (Appendix 3), follow –up until discharge or death.

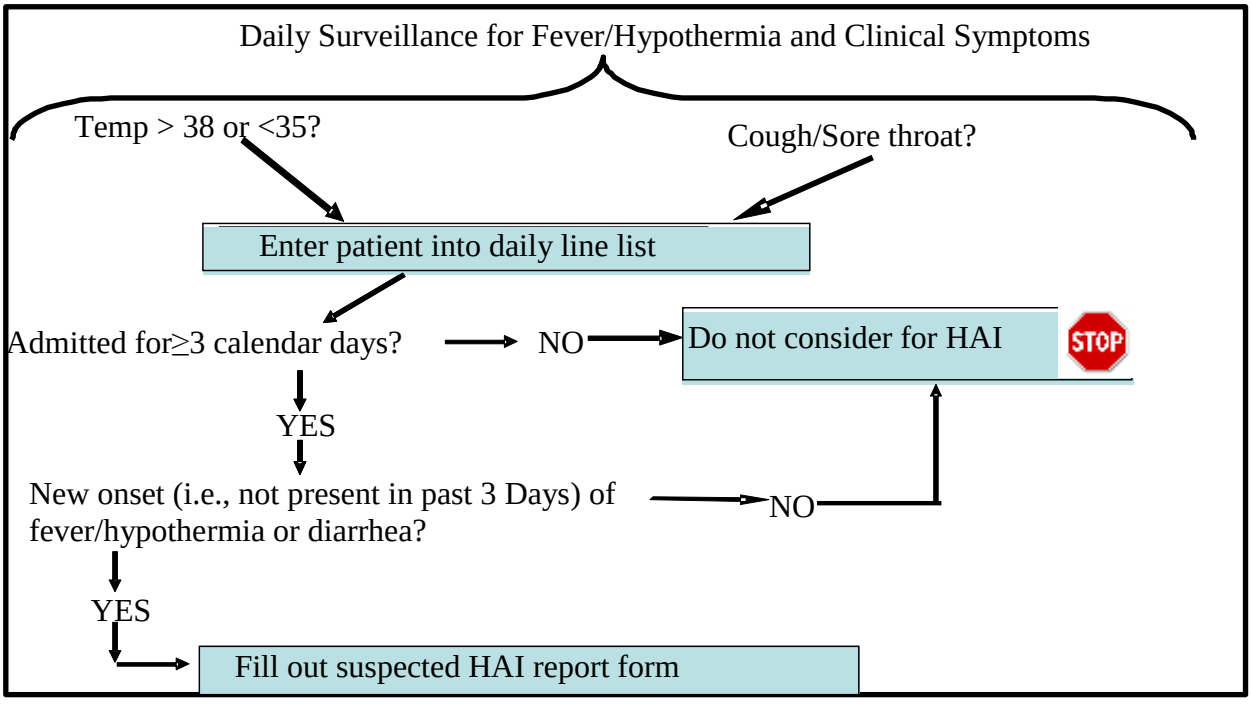

Figure 3.2 : Flow diagram for identifying patients with suspected healthcare infection

3.6 Collection of nasal-pharyngeal and oropharyngeal specimens from patients with HAIs

3.6.1 Case definitions

a. Suspected HAI was defined as any new onset fever ≥38 °Celsius or new onset hypothermia, ≤35 °Celsius that occurred ≥ three calendar days after hospital admission. This case definition was adapted from the US CDC's National Nosocomial Infections Surveillance system criteria for identification of specific types of HAIs (Slinger and Dennis, 2002; Forster *et al.*, 2004).
b. A case of suspected respiratory HAI was defined as a patient meeting case definition of suspect HAI and has the following;
    - New onset of cough or sore throat plus one of the following symptoms (for which there was no other evident cause): rhinorrhoea, difficulty in breathing, oxygen desaturation/increased ventilator demand and positive signs of pneumonia on chest X-ray.
c. A laboratory confirmed case of Respiratory HAI: Any suspected HAI cases with a positive laboratory result. Laboratory confirmed cases must test positive for the virus antigen, by detection of virus RNA by reverse transcriptase-polymerase chain reaction (RT- PCR).

3.6.2 Collection of respiratory HAI specimens

Patients meeting the case definition for respiratory HAI were asked to consent for specimen collection (Appendix 7 to 11). The specimen collection form is included in Appendix 6. Nasal-pharyngeal and oropharyngeal specimens were obtained according to the following procedure:

a) a sterile dacron-tipped cotton-shafted OP swab touched the back of the oropharyngeal mucosal membrane for 3-5 seconds and then was placed into a cryovial containing 1 mL of viral transport media without antibiotic;

b) a dacron-tipped flexible aluminum-shafted NP swab was inserted into the nose and back to the nasopharynx, where it was rotated 180 degrees and left in place for 3-5 seconds. The swab was inserted into the cryovial containing the OP swab from the same patient.

The specimens were labelled and transported at 4^{o}C to the KEMRI/CDC-K laboratory, where they were tested for the following respiratory pathogens using real-time Reverse Transcription-Polymerase Chain Reaction (rtRT-PCR): Influenza A and B, RSV, Adenovirus, PIV 1, 2, 3, *Human metapneumovirus*, *Mycoplasma, Legionella, rhino-entero* and *Chlamydia*. Specimens' positive for influenza A were further subtyped for 2009 Pandemic Influenza A H1N1, seasonal H1, H3 and H5. For rt RT-PCR, total RNA was extracted from 100 µL aliquots of each specimen using QIAamp viral RNA minikit (Qiagen Inc., GmbH, Germany) according to manufacturer's instructions. One step rtRT-PCR was carried out using the AgPath kit (Applied Biosystems, California, USA). Pathogen-specific primers were used (Appendix 5).

Specimens were tested following the reverse transcription step, a typical 45 cycle PCR reaction was run and fluorescence was read at the annealing/extension step. Appropriate negative and positive control specimens were run alongside each reaction. The results were recorded as cross-over threshold (C_T) values. Any pathogen C_T value $\leq$ 39.9 was recorded as positive; C_T value 40.0 – 44 were considered indeterminate, and those without a C_T reading were recorded as negative.

3.7 Hand hygiene

Throughout the study period, hand hygiene audits were done in the surveillance wards (Appendix 12). The Hand hygiene tool was adapted from the WHOs Guide to Implementation of a Multimodal Hand Hygiene Improvement Strategy (http://www.who.int/gpsc/5may/Guide_to_Implementation.pdf).

A trained hospital data collection officer collected hand hygiene (HH) data throughout the course of their surveillance duties. This was to minimize observation bias, which is a problem with traditional auditing methods. No identifying information about the healthcare worker under observation was recorded. The data collection officer only recorded whether or not HH was performed, the profession of the healthcare worker, and the indication for hand hygiene (defined by the WHO as: before patient care, before an aseptic task, after exposure to bodily fluid, after patient contact, and after contact with a contaminated surface.

3.8 Ethical considerations

This study was approved by the Institutional Review Board of CDC-Atlanta (IRB #5676) and the Ethical Review Committee of KEMRI (SSC #1571) (Appendix 13). HAI surveillance officer obtained written informed consent from every suspected HAI patient (Appendix 5) or, in the case of minors < 7years old, from the guardian. Separate assent forms were provided for children aged 7 to 14 years (Appendix 11). A parent, or guardian, was allowed to consent for patients who were unable to give consent because of their medical status. Information was given in English, Kiswahili, or the local language if indicated. Patients and guardian were able to refuse to participate. If the patient or guardian was illiterate, the surveillance officer read the consent.

3.9 Data management and analysis

The completed forms were manually entered into a Microsoft Access 2007 database and cleaned for errors and inconsistent answers. All identifying data were kept strictly confidential at the local hospital. Data was analyzed using SAS, version 9.3 for Windows (SAS institute Inc. cary, NC 27513, USA. Categorical variables were expressed as percentages, and continuous variables were expressed as means and standard deviation (SD). Percentages were compared using Chi-squared test and means were compared using student's t-test. A p value ≤ 0.05 was considered to be statistically significant.

Bivariate and multivariate logistic regression models were used to assess potential factors associated with respiratory HAI, including sex, age, ward type hospital, history of previous hospitalization, having urinary tract infections, central catheter insertion, being cared for by a family member, and outcome of hospitalization. Factors with P-values < 0.20 in bi-variate analyses were included in multivariate models. Odds ratios (OR) and 95% confidence intervals (CI) were calculated. Odds ratios (OR) from multivariate models were adjusted for age and P values <0.05 were considered statistically significant.

Incidence of respiratory HAIs was calculated by dividing the number of Respiratory HAIs identified by the number of patient days under surveillance. The patient-day denominator was determined from monthly ward-specific bed occupancy data provided by each hospital medical records department.

All patient days rather than patient days at risk (eliminating patient days for those discharged from the hospital after a stay <3 days), was used because using overall patient days has become standard protocol where most patient days are contributed by patients with lengths of stay >3 days (Cohen *et al.*, 2008). The incidence rates of respiratory HAI were calculated overall and by hospital and ward type. Pathogen test results were summarized for patients with respiratory HAI.

CHAPTER FOUR

RESULTS

4.1 Introduction

The study was carried out from 1st Sep 2009 to 31st July 2010. This resulted to 218,504 patients' days at the 3 hospitals: 5696 (2.6%) were on burns ward, 15275(7.0%) were in ENT, 9121(4.2%) were in eye ward, 12462 (5.7%) were in intensive care units (ICUs), 72707 (33.3%) were in paediatric, 52748 (24.1%) in medical wards, 8002 (3.7%) were in RIDD, and 42493 (19.4%) were on surgical wards (Table 4.1). The median length of stay was 22 days (2-447days).

Table 4.1. Characteristics of the facilities, 1st Sep 2009- 31st July 2010

Variable	No. of Beds n (%)	Surveillance period, days n (%)	Total no. of patients admitted n (%)	Total Patient-Days Under Surveillance n (%)
Hospital				
KNH	330(47.1)	297(42.6)	8385(35.3)	107,864(49.4)
NNPGH	253(36.1)	168(24.1)	8998(37.9)	61,459(28.1)
MDH	117(16.7)	232(33.3)	6368(26.8)	49,181(22.5)
TOTAL	**700(100)**	**697(100)**	**23751(100)**	**218,504(100)**
Wards				
Burns	22(3.1)	68(9.8)	367(1.5)	5696(2.6)
ENT	40(5.7)	39(5.6)	1734(7.3)	15275(7.0)
EYE	41(5.9)	48(6.9)	647(2.7)	9121(4.2)
ICU	26(3.7)	66(9.5)	937(3.9)	12462(5.7)
Paediatric	186(26.6)	157(22.5)	9216(38.8)	72707(33.3)
Medical	182(26.0)	177(25.4)	6603(27.8)	52748(24.1)
RIDD	42(6.0)	37(5.3)	243(1.0)	8002(3.7)
Surgical	161(23.0)	105(15.1)	3984(16.8)	42493(19.4)
TOTAL	**700(100)**	**697(100)**	**23731(100)**	**218504(100)**

RIDD= Respiratory Infectious Disease Department
KNH=Kenyatta National Hospital
NNPGH=New Nyanza Provincial General hospital
MDH=Mbagathi District Hospital
ICU=Intensive Care Unit
ENT=Ear, Nose and Throat ward

4.2 Demographic characteristics of the study subjects

A total of 1260 (including 443 patients with >1episodes) patients, were identified with new onset of fever or hypothermia, resulting in 2111 cases of new onset of fever/or hypothermia. Of these 406 (including 26 patients with >1episodes) patients met the case definition of suspected healthcare associated infection (Suspect HAI). Of the 406 patients identified with suspected HAI, 206 (50.7%) were identified at NNPGH, 132 (32.5%) of them were from KNH, and 68 (16.8%) from MDH. Of the 406 suspected HAI patients identified, 190 (46.9%) were in paediatric wards, 96 (23.7%) were in medical, 45 (11.1%) were in ICUs, 30 (7.4%) were in surgical and 24 (5.9%) were in Burns. A total of 227 (55.9%) of the study subjects were males and 179 (44.1%) were females (Table 4.2).

The median length of stay in the ward prior to new fever onset was 8 days (range, 3 to 768 days). There was statistically significant difference in length of stay prior to new fever onset according to hospital ($p<0.05$). The median length of stay was significantly higher ($p<0.05$) at Kenyatta National Hospital (14 days, range, 3 to 768 days) compared to New Nyanza PGH (6 days, range 3 to 394 days).The median duration between HAI onset and outcome was 10 days (Range: 1 to 560 days) for the 396 patients for whom this information was available. There was statistical significant difference in the duration of stay from HAI onset to patient outcome according to hospital ($p<0.05$).

Of 406 patients identified with suspected HAI, 155 (38.2%) met the case definition for respiratory HAI. Of the 155 patients who met case definition for respiratory HAI 2 (1.3%) had two episodes of respiratory HAI and 1 (0.6%) had three episodes.

Table 4.2. Demographic characteristics of study subjects, 1st Sep 2009- 31st July 2010

Variable	Suspected HAI n=406 (%)	P-Value
Hospital		
KNH	132(32.5)	
MDH	68(16.8)	<0.0001
NNPGH	206(50.7)	
Wards		
Burns	24(5.9)	
ENT	4(1.0)	
EYE	8(2.0)	
ICU	45(11.1)	<0.0001
Medical	96(23.7)	
Paediatric	190(46.9)	
RIDD	9(2.2)	
Surgical	30(7.4)	
Sex		
Male	227(55.9)	0.0224
Female	179(44.1)	
Age in years		
0 to 4	156(38.4)	
5 to 9	44(10.8)	
10 to 14	21(5.2)	
15 to 19	17(4.2)	
20 to 24	22(5.4)	
25 to 29	27(6.7)	
30 to 34	31(7.6)	<0.0001
35 to 39	27(6.7)	
40 to 44	11(2.7)	
45 to 49	8(2.0)	
50 to 54	17(4.2)	
55 to 59	9(2.2)	
60 to 64	7(1.7)	
Over 65	9(2.2)	
Total	**406(100)**	

Key:

HAI=Healthcare Associated Infection
RIDD= Respiratory Infectious Disease Department
KNH=Kenyatta National Hospital
NNPGH=New Nyanza Provincial General hospital
MDH=Mbagathi District Hospital
ICU=Intensive Care Unit
ENT=Ear, Nose and Throat ward

4.3 Respiratory HAI

4.3.1 Age and sex distribution of the study subjects

Table 4.3 shows the demographic characteristics of patients identified with respiratory HAI. The mean age of patients identified with respiratory was 18.2 (SD=19.4) years (range 0.2-87 years), 57 (36.8%) were females and 98 (63.2%) were males. Specific age distribution revealed 72 (46.5%) was less than five years. There was statistically significant difference in age, and sex of the patients identified with respiratory HAI ($p<0.05$).

A total of 161 episodes of Respiratory HAI, were identified in 155 patients between September 1, 2009 and July 31, 2010. Of the 155 respiratory HAI patients identified, 90 (58.1%) were identified at KNH, 35 (22.6%) at NNPGH and 30 (19.4%) at MDH. Of the 155 patients identified with respiratory HAI, 75 (48.4%) were in paediatric wards, 21 (13.5%) were in medical, 40 (25.8%) were in ICUs, 4 (2.6%) were in surgical and 4 (2.6%) were in Burns. There was statistically significant variation by ward type ($p<0.05$).

The median length of stay in the ward prior to new fever onset was 10 days (range, 3 to 768 days). There was statistically significant difference in length of stay prior to new fever onset according to hospital ($p<0.05$). The median length of stay was significantly higher ($p<0.05$) at Kenyatta National Hospital (14 days, range, 3 to 768 days) compared to New Nyanza PGH (6 days, range 3 to 394 days).The median duration between respiratory HAI onset and outcome was 14 days (Range: 0 to 560 days) for the 150 patients for whom this information was available. There was statistical significant difference in the duration of stay from respiratory HAI onset to patient outcome according to hospital ($p<0.05$).

Table 4.3. Demographic distribution of 155 patients with Respiratory HAIs in Kenya, 1st Sep 2009- 31st July 2010

Variable	Patients N=155	Percentage (%)	P-Value
Sex			
Male	98	63.2	0.0010
Female	57	36.8	
Age in years			
0 to 4	72	46.5	
5 to 9	10	6.6	
10 to 14	4	2.6	
15 to 19	2	1.3	
20 to 24	8	5.2	
25 to 29	8	5.2	
30 to 34	16	10.3	<0.0001
35 to 39	12	7.7	
40 to 44	4	2.6	
45 to 49	3	1.9	
50 to 54	5	3.2	
55 to 59	6	3.9	
60 to 64	2	1.3	
Over65	3	1.9	
Mean age of patients(SD)	18.2 (20.4)	N/A	<0.0001
Hospital			
KNH	90	58.1	<0.0001
NNPGH	35	22.6	
MDH	30	19.4	
Wards			
Burns	4	2.6	<0.0001
ENT	4	2.6	
EYE	3	1.9	
ICU	40	25.8	
Paediatric	75	48.4	
Medical	21	13.6	
RIDD	4	2.6	
Surgical	4	2.6	
Total	**155**	**100**	
Length of stay(days) to HAI onset, Median (Min-Max) n=155	10(3-768)	N/A	<0.0001

Key:

p<0.05 significant
SD = standard deviation
ICU=Intensive Care Unit
RIDD= Respiratory Infectious Disease Department
NNPGH=New Nyanza Provincial General hospital
KNH=Kenyatta National Hospital
MDH=Mbagathi District Hospital
ENT=Ear, Nose and Throat ward

4.3.2 Clinical characteristics of the study subjects

Table 4.4 shows the clinical characteristics of 155 patients identified with respiratory HAIs in the three hospitals. Of the 155 patients identified, 97 (62.6%) had features of influenza like illness (ILI), 24 (15.5%) had history of previous hospitalization in the past one month. The 155 patients identified with respiratory HAI, 126(81.3%) were cared for by a family member, 81 (64.3%) of these the family member/ friends stayed with the patients for >12 hours in a day. Of the 155 patients with respiratory HAI, 90 (58.1%) were discharged from the hospital, 41 (25.5%) died, 2 (1.3%) transferred, 8 (5.2%) absconded and 13 (8.4%) were still in the hospital at the final date of data collection.

Only 22 (14.2%) of the patients with respiratory HAI had their haemogram done, of which 6 (27.3%), had white blood cell count above the upper limit of normal. Thirty four (21.9%) of the patients were started on antibiotics on the day of, or within two days after developing new fever or hypothermia.

There was statistically significant variation between the patient cared for by relative or friends, having influenza like illness, the duration the relatives or friends stayed with the patient, those who had previous history of hospitalization, and having a peripheral line or central line catheter ($p<0.05$).

Table 4.4. Clinical characteristics 155 patients with Respiratory HAIs, in three hospitals, Kenya, 1st Sep 2009- 31st July 2010

Variable	Patients N=155	Percentage (%)	P-Value
Influenza like illness(ILI)			
Yes	97	62.6	0.0017
No	58	37.4	
Haemogram done within fever period			
Yes	22	14.2	<0.0001
No	133	85.8	
White Blood Cell count above the upper limit of normal			
Yes	6	27.3	<0.0001
No	16	72.7	
Patient started on antibiotics after new fever onset			
Yes	34	21.9	
No	45	29.0	<0.0001
Not indicated	76	49.0	
Had history of previous hospitalization			
Yes	24	15.5	<0.0001
No	131	84.5	
Cared for by family member			
Yes	126	81.8	
No	17	11.0	<0.0001
Unknown	12	7.7	
How often friends and family are with patient in the hospital			
<1 hr	39	31.0	
1-5hrs	5	4.0	<0.0001
6-12hrs	1	0.8	
>12hrs	81	64.3	
Central line in place within 2 days of fever/ hypothermia onset			
Yes	35	22.6	<0.0001
No	120	77.4	
Had branula /IV in place within 2 days of fever/hypothermia onset			
Yes	50	32.3	<0.0001
No	105	67.7	
Had Blood stream infection (BSI)			
Yes	10	6.5	<0.0001
No	145	93.5	
Had Urinary tract infection (UTI)			
Yes	21	13.5	<0.0001
No	134	86.5	
Outcome			
Absconded	8	5.2	
Discharged	90	58.1	
Transferred	3	1.9	<0.0001
Death	41	26.5	
Still in the wards	13	8.4	

Key: $p<0.05$ significant

4.3.3 The incidence of Respiratory HAI among the study subjects

The cumulative occurrence rate among the respondents' was 155 (38.2%). The incidence rate among men was 98 (43.2%) higher than their female counterparts 57 (31.8%).

The overall incidence density of Respiratory HAI, was 0.80 (95% CI, 0.70 – 0.90) infections/1000 patients' days (Table 4.5). The incidence density of respiratory HAI was not significantly different across the three hospitals; it was 0.9 per 1000 patients days at the KNH, 0.8 per 1000 patients at NNPGH and 0.6 per 1000 patients at the MDH ($p<0.05$). However, compared to the medical ward (0.4/1000 patient-days), the incidence density of respiratory HAI were significantly higher in the ICU (5.5/1000patient days, $p<0.05$), paediatric (1.1/1000patient days, $p<0.05$) and eye (3.3/1000patient days, $p<0.05$) wards. Incidence density of respiratory HAI was significantly lower in the surgical wards.

There was no statistically significant difference in the incidence density of respiratory HAI in the burns ward, RIDD compared to the medical wards.

Table 4.5. Incidence density of respiratory HAI Patients by hospital and ward type per 1000 patient-days

Surveillance ward	# of cases	Incidence rate (95% CI)	Infections per 1,000 patients days	IRR (95% CI)	p-value
Hospital					
KNH	90	0.0009(0.0007-0.0011)	0.9	Ref	
NNPGH	35	0.0008(0.0005-0.0010)	0.8	0.84(0.58-1.21)	0.344
MDH	30	0.0006(0.0004-0.0009)	0.6	0.68(0.45-1.03)	0.071
Ward type					
Medical	21	0.0004(0.0002-0.0006)	0.4	Ref	
ICU	40	0.0055(0.0039-0.0075)	5.5	14.43(8.53-24.41)	<0.001*
Pediatrics	75	0.0011(0.0009-0.0013)	1.1	2.83(1.75-4.58)	<0.001*
Surgical	4	0.0001(0.00003-0.0003)	0.1	0.29(0.10-0.85)	0.024*
Burns unit	4	0.0007(0.0002-0.0017)	0.7	1.84(0.63-5.37)	0.262
RIDD	4	0.0005(0.0001-0.0013)	0.5	1.31(0.45-3.82)	0.619
ENT	4	0.0003(0.00007-0.0007)	0.3	0.69(0.24-2.00)	0.492
EYE	3	0.0033(0.0007-0.0095)	3.3	8.54(2.55-28.63)	0.001*
Total	**155**	**0.0008(0.0007-0.0009)**	**0.8**		

Key:

* P < 0.05

CI= Confidence interval

IRR= incidence rate ratio

ICU=Intensive Care Unit

RIDD= Respiratory Infectious Disease Department

NNPGH=New Nyanza Provincial General hospital

HAI=Healthcare Associated Infection

KNH=Kenyatta National Hospital

MDH=Mbagathi District Hospital

ENT=Ear, Nose and Throat ward

4.3.5 Trend of Respiratory HAI over the study period

Rates of respiratory HAIs varied not only among wards and hospitals but also by month within wards. Respiratory HAIs were detected throughout the year without any clear seasonal trends. The aggregate monthly respiratory HAI rates varied between 0.4 and 1.1 infections per 1000 patients-days.

There was a notable decline in case identification that occurred at KNH from November 2009 to March 2010. There was sharp increase in respiratory HAI rates occurring between March and July 2010 at the NNPGH (Figure 4.1).

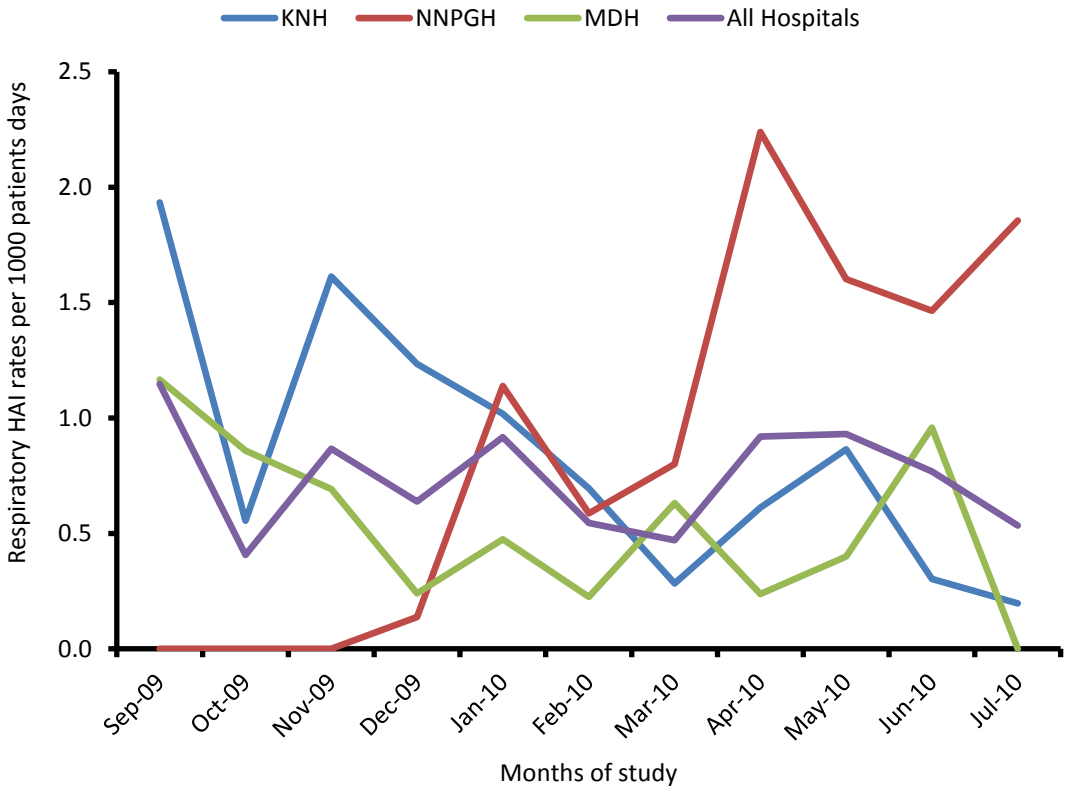

Figure 4.1 : Overall respiratory HAI incidence per 1000 patient-days reported by hospital, Kenya Sep 2009-July 2010

4.3.6 The viruses associated with respiratory HAIs, in the three hospitals

Of the 155 (38.2%), patients with Respiratory HAI, 143 (92.3%), met the criteria to have the nasopharyngeal (NP) and oropharyngeal (OP) samples' taken for virology. Of these 131 (91.6%) patients' had their samples taken, 6 (4.2%) patients no sample was taken from them, 6(4.2%) were too sick and others uncooperative despite consenting. Of the 131 samples tested, 56 (42.7%) were positive for at least one virus by rRT-PCR (Table 4.7), detection being higher among paediatric patients (80.4%) than medical patients (3.6%, ($p<0.05$). The most common viruses identified were, RSV 21 (16.0%), adenovirus 14 (10.7%), PIV3 17 (13.0%), and influenza A 12 (9.2%). Of those having influenza A, 5 (41.7%) had pH1N1 and 3 (25%) had H3N2. Seventy-nine pathogens were recovered from 56 patients who fulfilled the definition of laboratory confirmed respiratory HAI.

Multiple viruses were recovered for 17 (12.8%) patients, 13 (76.5%) of these patients had dual viruses identified, 317.6 (%) had triple and 1 (5.9%) had four viruses identified. Fourteen (82.4%) of the multiple viruses were at KNH, 2 (11.8%) NNPGH and 1 (5.9%) at MDH.

Table 4.6. Distribution of viral pathogens by hospital recovered from patients with respiratory HAI

Variable	KNH (N= 86) n (%)	NNPGH (N=20) n (%)	MDH (N=25) n (%)	*Total (N=131) n (%)
None	52(60.5)	11(55.0)	13(52.0)	**76(58.0)**
RSV	17(19.8)	1(5.0)	3(12.0)	**21(16.0)**
Adenovirus	10(11.6)	2(5.0)	3(12.0)	**15(11.5)**
Influenza A	6(7.0)	1(5.0)	5(20.0)	**12(9.2)**
pH1N1	1/6(16.7)	1/1(100.0)	4/5(80.0)	**5/12(41.7)**
Seasonal H1N1	0(0.0)	0(0.0)	0(0.0)	**0(0.0)**
H3N2	2/6(33.3)	1/1(100.0)	0(0.0)	**3/12(25.0)**
Influenza B	1(1.2)	2(10.0)	2(8.0)	**5(3.8)**
Para-influenza virus 1	3(3.5)	1(5.0)	0(0.0)	**4(3.1)**
Para-influenza virus 2	1(1.2)	1(5.0)	0(0.0)	**2(1.5)**
Para-influenza virus 3	13(15.1)	1(5.0)	3(12.0)	**17(13.0)**
Human metapneumovirus	2(2.3)	1(5.0)	0(0.0)	**3(2.3)**

*Total number of samples tested

Figure 4.2 show the distribution by type of ward and patients identified with positive viruses identified in 131 samples collected from patients with respiratory HAI by type of ward. There were 64 samples obtained from paediatrics, 13 from medical wards, 4 from surgical and 50 from special wards (ICU, ENT, EYE, RIDD and burns). Patients with multiple viruses were identified mostly in paediatric wards, where 16 (94.1%) of the 17 the patients with multiple viruses identified occurred.

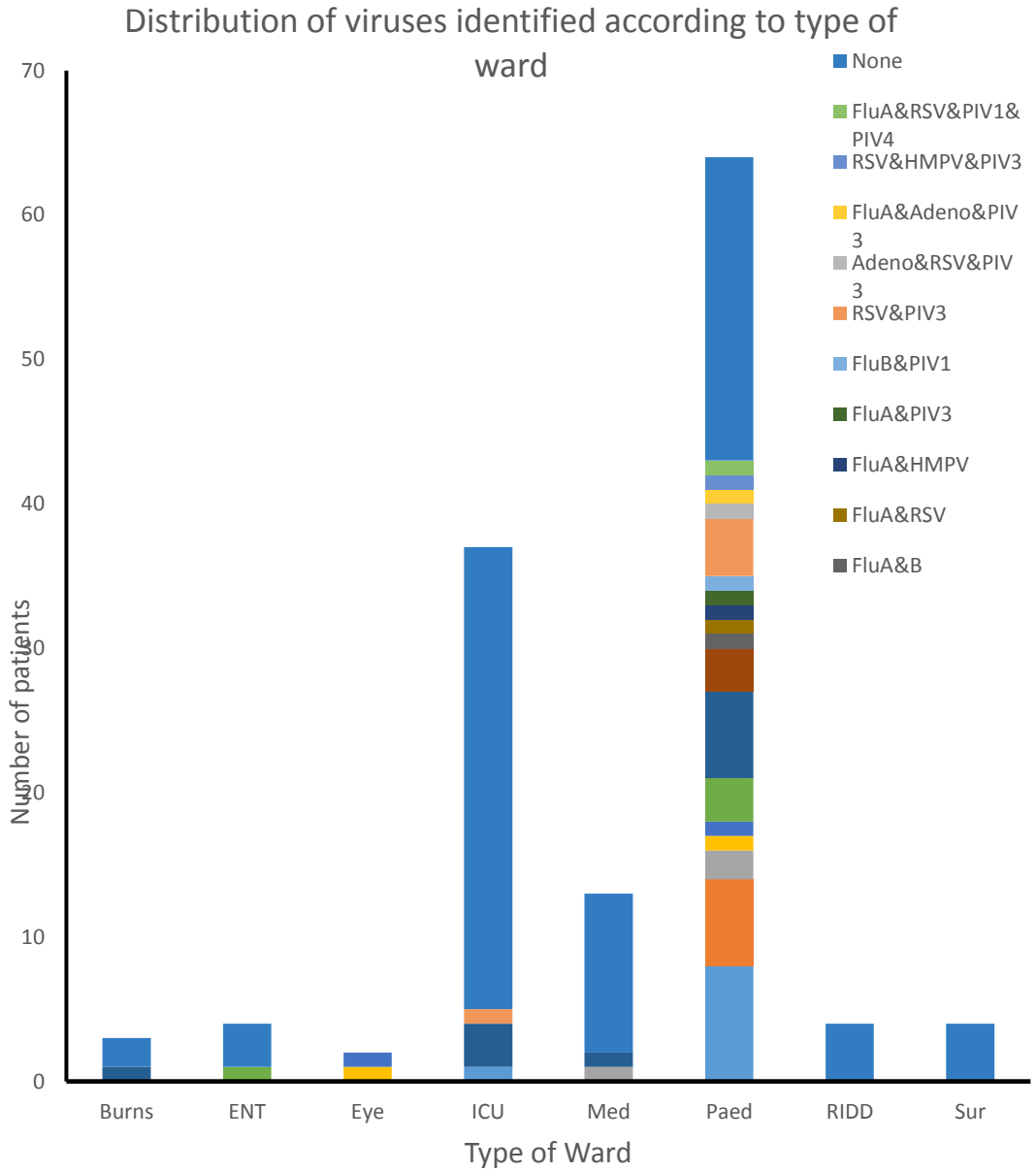

Figure 4.2: Distribution of patients with confirmed virus according to type of ward

4.4 The risk factors for respiratory viral HAIs

4.4.1 Bi-variate and logistic-regression analyses of potential risk factors for the acquisition of Respiratory HAI

Bivariate analysis for potential risk factors was carried out for each of the variables that was found to be significant in the single variable analysis. Chi square analysis demonstrated that the following single variables were significant: hospital type, ward type, sex, Age of the patient, outcome, history of previous hospitalization, cared for by relatives or family member, having urinary tract infections or blood stream infection.

4.4.4.1 Demographic characteristics: potential risk factors for the acquisition of Respiratory HAI

Table 4.7 shows bivariate analysis of demographic characteristics of patients with respiratory HAI and those patients with no respiratory HAI. Bivariate analysis, showed being in NNPGH (OR=0.10; 95% CI 0.06-0.16; $p<0.05$), or in MDH (OR=0.35; 95% CI 0.19-0.64; $p<0.05$), was more likely to develop respiratory HAI compared to KNH. In addition, patients less than 5years (OR=0.35; 95% CI 0.18-0.68; $p<0.05$), those admitted in ICU (OR=17.57; 95% CI 7.38-41.84; $p<0.05$), and those in paediatric wards (OR=2.37; 95% CI 1.36-4.14; $p<0.05$), were significantly associated with developing respiratory HAI.

Table 4.7. The results of the bi-variate and logistic-regression analyses of potential risk factors for the acquisition of Respiratory HAI at three selected hospitals in Kenya from 1st Sep2009-31st July 2010

Variable	Had a Respiratory HAI n=155 (%)	Had no Respiratory HAI N=251 (%)	Odds Ratio (95% CI)	P-value
Hospital				
KNH	90(58.1)	42(16.7)	**Reference**	
MDH	30(19.4)	38(15.1)	0.35(0.19-0.64)	0.001*
NNPGH	35(22.6)	171(68.1)	0.10(0.06-0.16)	<0.001*
Wards				
Medical	21(13.6)	75(29.9)	**Reference**	
Burns	4(2.6)	20(8.0)	0.77(0.24-2.50)	0.666
ENT	4(2.6)	0(0)	>9.99(<0.001->999)	0.9566
EYE	3(1.9)	5(2.0)	2.31(0.51-10.49)	0.277
ICU	40(25.8)	5(2.0)	17.57(7.38-41.84)	<0.001*
Paediatric	75(48.4)	115(45.8)	2.37(1.36-4.14)	0.002*
RIDD	4(2.6)	5(3.0)	3.09(0.76-12.53)	0.115
Surgical	4(2.6)	26(10.4)	0.59(0.19-1.89)	0.377
Sex				
Male	98(63.3)	129(51.4)	**Reference**	
Female	57(36.8)	122(48.6)	0.55(0.37-0.82)	0.004*
Age in years				
0 to 4	72(46.5)	84(33.5)	**Reference**	
5 to 9	10(6.5)	34(13.6)	0.34(0.16-0.74)	0.126
10 to 14	4(2.6)	17(6.8)	0.28(0.09-0.85)	0.144
15 to 19	2(1.3)	15(6.0)	0.16(0.03-0.70)	0.058
20 to 24	8(5.2)	14(5.6)	0.67(0.27-1.68)	0.813
25 to 29	8(5.2)	19(7.6)	0.49(0.20-1.19)	0.630
30 to 34	16(10.3)	15(6.0)	1.24(0.58-2.69)	0.047*
35 to 39	12(7.7)	15(6.0)	0.93(0.41-2.12)	0.259
40 to 44	4(2.6)	7(2.8)	0.67(0.19-2.37)	0.863
45 to 49	3(1.9)	5(2.0)	0.70(0.16-3.03)	0.826
50 to 54	5(3.2)	12(4.8)	0.49(0.16-1.45)	0.681
55 to 59	6(3.9)	3(1.2)	2.33(0.56-9.67)	0.044*
60 to 64	2(1.3)	5(2.0)	0.47(0.09-2.48)	0.749
Over 65	3(1.9)	6(2.4)	0.58(0.14-2.42)	0.964
Length of Stay (days) in the Ward, median (min-max)	27(5-373)	45.5(8-181)	N/A	

Key:

CI= Confidence interval
ICU=Intensive Care Unit
RIDD= Respiratory Infectious Disease Department
NNPGH=New Nyanza Provincial General hospital
HAI=Healthcare Associated Infection
KNH=Kenyatta National Hospital
MDH=Mbagathi District Hospital
ENT=Ear, Nose and Throat ward

4.4.4.2 Clinical characteristics of potential risk factors for the acquisition of Respiratory HAI

Table 4.8 shows bivariate analysis of clinical characteristics of patients with respiratory HAI and those patients with no respiratory HAI. Patients who stayed with friends or family members in the ward for more than 5 hours were more like to develop respiratory HAI compared to those who stayed with friend or family members for less than one hour (OR=0.01; 95% CI 0.00-0.05; $p<0.05$). Having history of previous hospitalization (OR 0.89; 95% CI 0.52 to 1.50); those aged between 55 and 59 (OR 2.33; 95% CI 0.56 to 9.67; $p<0.05$), having blood stream infection (OR=9.34; 95% CI 2.02-43.30; $p<0.05$), urinary tract infection (OR=12.95; 95% CI 3.78-44.4; $p<0.05$),and having an indwelling central catheter (OR=40.28; 95% CI 9.53-170.25; $p<0.05$), was not significantly associated with respiratory HAI.

Table 4.8. Bi-variate and logistic-regression analyses of clinical characteristics of Respiratory HAI at three selected hospitals in Kenya from 1st Sep2009-31st July 2010

Variable	Had a Respiratory HAI n=155 (%)	Had no Respiratory HAI N=251 (%)	Odds Ratio (95% CI)	P-value
Had history of previous hospitalization				
No	131(84.5)	210(83.7)	**Reference**	
Yes	24(15.5)	41(16.3)	0.89(0.52-1.50)	0.654
Had Urinary Tract Infections (UTI)				
No	134(86.4)	248(98.8)	**Reference**	
Yes	21(13.6)	3(1.2)	12.95(3.78-44.4)	<0.001*
Had blood stream infection (BSI)				
No	145(93.5)	249(99.2)	**Reference**	
Yes	10(6.5)	2(0.8)	9.34(2.02-43.30)	0.004*
Central catheter in place within 2days of new fever/hypothermia onset				
No	120(77.2)	249(99.2)	**Reference**	
Yes	35(22.6)	2(0.8)	40.28(9.53-170.25)	<0.001*
Peripheral line in place within 2days of new fever/hypothermia onset				
No	106(68.4)	154(61.3)	**Reference**	
Yes	49(31.6)	97(38.7)	1.20(0.65-2.22)	0.56
Cared for by family member				
No	30(19.3)	44(17.5)	**Reference**	
Yes	125(80.7)	207(82.5)	1.20(0.65-2.22)	0.56
How often friends and family are with patient in the hospital (n=125 and 206)				
<1 hr	39(31.2)	12(5.8)	**Reference**	
1-5hrs	5(4.0)	4(1.9)	0.46(0.11-1.91)	0.287
6-12hrs	1(0.8)	41(19.9)	0.01(0.00-0.05)	<0.001*
>12hrs	80(64.0)	149(72.3)	0.16(0.08-0.31)	<0.001*

Key:

CI= Confidence interval

4.4.2 Multi-variate analyses of patients who had Respiratory HAI

In multivariate analysis, (Table 4.9), of the patients who had respiratory HAI adjusting for confounding by age and hospital; there was evidence of confounding by age. When age was included as a confounder, sex (aOR=0.58, 95% CI 0.37-0.92; p<0.05), having urinary tract infection (aOR= 5.03, 95% CI 1.42-17.84; p<0.05), having a central catheter (aOR= 40.50, 95% CI 9.20-178.31; p<0.05), being cared for by family/relatives for >6hours (aOR= 0.03, 95% CI 0.00-0.26; p<0.05), and death (aOR= 1.76, 95% CI 1.02-3.05; p<0.05) were significantly associated with having a respiratory HAI. Other factors found to be associated with having a respiratory HAI were type of ward, being in ICU compared to medical ward (aOR=12.62, 95% CI 4.70-33.88; p<0.05); duration of care by family/relatives, and outcome of hospitalization. Patients who died were more likely to develop a respiratory HAI compared to those who were discharged (aOR= 1.76, 95% CI 1.02-3.05; p<0.05). Patients who were discharged, absconded, referred, or were still in hospital were equally likely to develop respiratory HAI.

Table 4.9. Multivariate analysis of the patients who had respiratory HAI adjusting for confounding by age and hospital n=131

Variable	Crude Odds Ratio (95% CI)	p-value	Odds Ratio (95% CI)	p-value
Sex				
Male	Reference		Reference	
Female	1.37(0.67-2.79)	0.391	0.58(0.37-0.92)	0.021*
Wards				
Medical	Reference		Reference	
ICU	0.86(0.14-5.12)	0.868	12.62(4.70-33.88)	<0.001*
Pediatrics	11.78(2.38-58.36)	0.003**	3.30(0.95-11.42)	0.060
Surgical	‡		0.33(0.10-1.09)	0.068
Burns unit	‡		1.20(0.27-5.22)	0.812
RIDD	‡		0.95(0.18-5.02)	0.950
Eye	‡		0.79(0.13-4.96)	0.802
Had Urinary Tract Infections (UTI)				
No	Reference		Reference	
Yes	0.41(0.14-1.22)	0.110	5.03(1.42-17.84)	0.012*
Had a Central catheter				
No	Reference		Reference	
Yes	0.20(0.07-0.55)	0.002*	40.50(9.20-178.31)	<0.001*
How often friends and family are with patient in the hospital				
<1 hr	Reference		Reference	
1-5hrs	‡		1.62(0.34-7.81)	0.545
6-12hrs	‡		0.03(0.00-0.26)	0.001*
>12hrs	10.43(3.80-28.68)	<0.001***	0.10(0.02-0.52)	0.006*
Outcome				
Discharged	Reference		Reference	
Absconded	1.23(0.26-5.92)	0.793	1.29(0.35-4.77)	0.707
Referred	1.85(0.16-21.46)	0.623	0.22(0.02-2.35)	0.212
Death	0.25(0.10-0.61)	0.002**	1.76(1.02-3.05)	0.044*
Still in Hospital	0.31(0.06-1.63)	0.167	1.09(0.52-2.27)	0.816

Key:

* $p < 0.05$
‡ Insufficient data to make the comparison
ICU=Intensive Care Unit
RIDD= Respiratory Infectious Disease Department
NNPGH=New Nyanza Provincial General hospital
HAI=Healthcare Associated Infection
KNH=Kenyatta National Hospital
MDH=Mbagathi District Hospital
ENT=Ear, Nose and Throat ward

4.4.3 Comparison of patients who had laboratory confirmed respiratory HAI and those who did not by selected characteristics

A total of 131 patients gave out OP/NP samples, and for the 56 laboratory positive respiratory HAI patients, 33/84 (39.3%) were males and 23/49 (46.9%) were females. There were marginally more females than males who tested positive for viral respiratory HAI among the respiratory HAI patients. There was no association between sex and testing positive for viral respiratory HAI ($p>0.05$) but the age of the patient showed significant association with viral respiratory HAI ($p<0.05$, Table 4.10).

Table 4.10. Comparison of patients who had Laboratory confirmed positive viral respiratory HAI and those who had negative viral respiratory HAI by sex and age

Variable	Had a positive Respiratory HAI (n=56) n(%)	Had negative Respiratory HAI (n=75) n(%)	p-value
Sex			
Male	33(58.9)	50(66.7)	0.3632
Female	23(41.1)	25(33.3)	
Age in years			
0 to 4	41(73.2)	19(25.3)	<0.0001*
5 to 9	6(10.7)	3(4.0)	
10 to 14	0(12.5)	3(4.0)	
15 to 19	1(1.8)	1(1.3)	
20 to 24	2(1.8)	4(5.3)	
25 to 29	1(1.8)	5(6.7)	
30 to 34	3(1.8)	13(17.3)	
35 to 39	1(1.8)	9(12.0)	
40 to 44	0(1.8)	2(2.7)	
45 to 49	0(1.8)	2(2.7)	
50 to 54	0(1.8)	5(6.7)	
55 to 59	1(1.8)	4(5.3)	
60 to 64	0(1.8)	2(2.7)	
Over 65	0(1.8)	3(4.0)	

Key:

* $p < 0.05$;

Table 4.11 shows comparison of patients who had laboratory confirmed positive viral respiratory HAI and those who had tested negative by selected characteristics. Although more than 50% of laboratory positive viral respiratory HAI were from KNH, Pearson chi-square test showed that there was no association between hospital and viral respiratory HAI status ($p>0.05$,).

Bivariate analysis of the patients who had respiratory HAI and tested positive for viral pathogen and those that tested negative demonstrated that among the risk factors measured in this study only, the type of the ward ($p<0.05$), being cared for by a relative of friend ($p<0.05$), having a central line ($p<0.05$), and outcome of the patient ($p<0.05$) were associated with development of respiratory HAI.

Respiratory HAI patients with any virus identified, 45 (80.4%) were from paediatric wards, and 34 (60.7%) were from KNH, there was significant differences in ward type ($p<0.05$).

Table 4.11. Comparison of patients who had Laboratory confirmed positive viral respiratory HAI and those who had negative viral respiratory HAI by selected characteristics

Variable	Had a positive Respiratory HAI (n=56) n(%)	Had negative Respiratory HAI (n=75) n(%)	p-value
Hospital			
KNH	34(60.7)	52(69.3)	
MDH	11(19.6)	14(18.7)	0.4481
NNPGH	11(19.6)	9(12.0)	
Wards			
Medical	2(3.6)	11(14.7)	
ICU	5(8.9)	32(42.7)	
Pediatrics	45(80.4)	19(25.3)	
Surgical	0(0.0)	4(5.3)	<0.0001*
Burns unit	1(1.8)	2(2.7)	
RIDD	0(0.0)	4(5.3)	
ENT	1(1.8)	3(4.0)	
Eye	2(3.6)	0(0.0)	
Central catheter insertion cases			
No	51(91.1)	49(65.3)	
Yes	5(8.9)	26(34.7)	0.0017*
Cared for by family member			
No	5(8.9)	19(25.3)	0.0417*
Yes	51(91.1)	56(74.7)	
How often friends and family are with patient in the hospital			
<1 hr	6(10.7)	32(42.7)	
1-5hrs	0(0.0)	3(4.0)	<0.0001*
6-12hrs	0(0.0)	0(0.0)	
>12hrs	45(80.4)	21(28.0)	
Outcome			
Discharged	40(71.4)	36(48.0)	
Absconded	4(7.1)	3(4.0)	0.0244*
Referred	1(1.8)	0(0.0)	
Death	8(14.3)	30(40.0)	
Still in Hospital	2(3.6)	5(6.7)	

Key:

* $p < 0.05$;

ENT=Ear, Nose and Throat ward
HAI=Healthcare Associated Infection
ICU=Intensive Care Unit
KNH=Kenyatta National Hospital
MDH=Mbagathi District Hospital
NNPGH=New Nyanza Provincial General hospital
RIDD= Respiratory Infectious Disease Department

4.4.4 Logistic-regression analyses of potential risk factors for those who had positive viral Respiratory HAI

4.4.4.1 Demographic characteristics: potential risk factors for those who had positive viral Respiratory HAI

Table 4.12 shows logistic regression of patients who had positive viral respiratory HAI and those who had negative viral respiratory HAI by selected characteristics. Those patients in paediatric ward (aOR=11.78; 95% CI 2.38-58.36; p<0.05), were significantly associated with a positive viral respiratory HAI compared to medical wards. The patients' age was grouped into five categories, of those under-fives years, 5years to 18 years, over 18 to 35 years, 35 to 50 years and over 50 years. This was to allow logistic regression, by age because some categories had few cases of respiratory HAI. Age of the patient was negatively associated with testing positive for a respiratory HAI.

The odds of having a positive respiratory HAI decreased from 1.0 for children aged below 5 years to 0.17 (95% CI 0.06-0.46; P<0.05) for those aged 18-34 years, 0.04 (95% CI 0.01-0.34; p<0.05) for those aged 35 to <50 and 0.04 (95% CI 0.00-0.31; P<0.05) for those aged 50 and above.

Table 4.12. Logistic regression of patients who had positive viral respiratory HAI and those who had negative viral respiratory HAI by selected characteristics

Variable	Had a positive Respiratory HAI (n=56) n(%)	Had negative Respiratory HAI (n=75) n(%)	Odds Ratio (95% CI)	p-value
Sex				
Male	33(58.9)	50(66.7)	Reference	
Female	23(41.1)	25(33.3)	1.37(0.67-2.79)	0.391
Age in years				
0-<5	41(73.2)	22(28.6)	Reference	
5-<18	6(10.7)	6(7.8)	0.54(0.15-1.87)	0.329
18-<35	7(12.5)	22(28.6)	0.17(0.06-0.46)	0.001**
35-<50	1(1.8)	13(16.9)	0.04(0.01-0.34)	0.003**
>50	1(1.8)	14(18.2)	0.04(0.00-0.31)	0.002**
Hospital				
KNH	34(60.7)	52(69.3)	Reference	
MDH	11(19.6)	14(18.7)	1.53(0.59-3.93)	0.378
NNPGH	11(19.6)	9(12.0)	1.20(0.49-2.97)	0.690
Wards				
Medical	2(3.6)	11(14.7)	Reference	
ICU	5(8.9)	32(42.7)	0.86(0.14-5.12)	0.868
Pediatrics	45(80.4)	19(25.3)	11.78(2.38-58.36)	0.003**
Surgical	0(0.0)	4(5.3)	‡	-
Burns unit	1(1.8)	2(2.7)	‡	-
RIDD	0(0.0)	4(5.3)	‡	-
ENT	1(1.8)	3(4.0)	2.75(0.16-47.34)	0.486
Eye	2(3.6)	0(0.0)	‡	-

Key:

* $p < 0.05$

‡ Insufficient data to make the comparison

ICU=Intensive Care Unit

RIDD= Respiratory Infectious Disease Department

NNPGH=New Nyanza Provincial General hospital

HAI=Healthcare Associated Infection

KNH=Kenyatta National Hospital

MDH=Mbagathi District Hospital

ENT=Ear, Nose and Throat ward

4.4.4.2 Demographic characteristics: potential risk factors for those who had positive viral Respiratory HAI

Table 4.13 shows logistic regression of patients who had positive viral respiratory HAI and those who had negative viral respiratory HAI by selected clinical characteristics. Patients who were cared for by a friend or family members were associated with having positive viral respiratory HAI compared to those who had no care taker (OR=5.28; 95% CI 1.12-24.84; P<0.05).

In fact those who stayed with friends or family members in the ward for more than 12 hours were more likely to develop respiratory HAI compared to those who stayed with friend or family members for a short period, less than one hour (OR=10.43; 95% CI 3.80-28.68; P<0.05).

Having history of previous hospitalization (OR 0.61; 95% CI 0.21 to 1.73; p=0.351); being in ENT ward (OR=2.75; 95% CI 0.16-47.34; p>0.05), ICU (OR=0.86; 95% CI 0.14 -5.12; p>0.05), and having a urinary tract infection (OR 0.41; 95% CI 0.14 to 1.22; p>0.05), was not significantly associated with respiratory HAI.

Table 4.13. Logistic regression of patients who had positive viral respiratory HAI and those who had negative viral respiratory HAI by selected characteristics

Variable	Had a positive Respiratory HAI (n=56) n(%)	Had negative Respiratory HAI (n=75) n(%)	Odds Ratio (95% CI)	p-value
Had history of previous hospitalization				
No	47(88.7)	62(82.7)	Reference	
Yes	6(11.3)	13(17.3)	0.61(0.21-1.73)	0.351
Had Urinary Tract Infections (UTI)				
No	50(90.9)	62(80.5)	Reference	
Yes	5(9.1)	15(19.5)	0.41(0.14-1.22)	0.110
Central catheter insertion cases				
No	51(91.1)	49(65.3)	Reference	
Yes	5(8.9)	26(34.7)	0.20(0.07-0.55)	0.002*
Cared for by family member				
No	5(8.9)	19(25.3)	Reference	
Yes	51(91.1)	56(74.7)	5.28(1.12-24.84)	0.035*
How often friends and family are with patient in the hospital				
<1 hr	6(11.8)	32(42.7)	Reference	
1-5hrs	0(0.0)	3(4.0)	‡	-
6-12hrs	0(0.0)	0(0.0)	‡	-
>12hrs	45(88.2)	21(28.0)	10.43(3.80-28.68)	<0.001***
Outcome				
Discharged	40(71.4)	36(48.0)	Reference	
Absconded	4(7.1)	3(4.0)	1.23(0.26-5.92)	0.793
Referred	2(3.6)	0(0.0)	1.85(0.16-21.46)	0.623
Death	8(14.3)	30(40.0)	0.25(0.10-0.61)	0.002**
Still in Hospital	2(3.6)	5(6.7)	0.31(0.06-1.63)	0.167

Key:

* $p < 0.05$

‡ Insufficient data to make the comparison

4.4.5 Age adjusted comparison of patients who had positive respiratory HAI

Table 4.14 shows the age adjusted comparison of patients who had positive respiratory HAI and those who had negative laboratory results. After adjusting for age, paediatric ward had a significantly higher proportion of patients who tested positive for respiratory HAI 45 (80%) compared to those in the medical ward 2 (3.6%) (Adj. OR=15.64; 95% CI 1.35-180.85; P<0.05). None of the other factors assessed were significantly associated with a positive outcome for respiratory HAI.

Table 4.14. Age adjusted comparison of patients who had positive respiratory HAI and those who had negative lab results (n=131)

Variable	Had a positive Respiratory HAI n(%)n=56	Had negative Respiratory HAI n(%) n=75	Age adjusted Odds Ratio (95% CI)	p-value
Wards				
Medical	2(3.6)	11(14.7)	Reference	
ICU	5(8.9)	32(42.7)	1.02(0.16-6.46)	0.983
Pediatrics	45(80.4)	19(25.3)	15.64(1.35-180.85)	0.028*
Surgical	0(0.0)	4(5.3)	‡	-
Burns	1(1.8)	2(2.7)	‡	-
RIDD	0(0.0)	4(5.3)	‡	-
ENT	1(1.8)	3(4.0)	3.23(0.11-98.82)	0.501
Eye	2(3.6)	0(0.0)	‡	-
Had Urinary Tract Infections (UTI)				
No	51(91.9)	62(80.5)	Reference	
Yes	5(9.1)	15(19.5)	1.69(0.38-7.63)	0.492
Central catheter insertion cases				
No	51(91.1)	51(66.2)	Reference	
Yes	5(8.9)	26(33.8)	0.85(0.18-4.00)	0.839
Cared for by family member				
No	5(8.9)	19(25.3)	Reference	
Yes	51(91.1)	56(74.7)	2.63(0.53-13.02)	0.235
How often friends and family are with patient in the hospital				
<1 hr	6(10.7)	32(42.7)	Reference	
1-5hrs	0(0.0)	3(4.0)	‡	-
6-12hrs	0(0.0)	0(0.0)	‡	-
>12hrs	45(80.4)	21(28.0)	7.23(0.64-81.92)	0.110
Outcome				
Discharged	40(71.4)	36(48.0)	Reference	
Absconded	4(7.1)	3(4.0)	0.89(0.18-4.27)	0.879
Referred	1(1.8)	0(0.0)	4.07(0.35-46.87)	0.260
Death	8(14.3)	30(40.0)	0.45(0.16-1.21)	0.113
Still in Hospital	2(3.6)	5(6.7)	0.22(0.03-1.47)	0.118

Key: * $p < 0.05$;
‡ Insufficient data to make the comparison
ENT=Ear, Nose and Throat ward
HAI=Healthcare Associated Infection
ICU=Intensive Care Unit
KNH=Kenyatta National Hospital
MDH=Mbagathi District Hospital
NNPGH=New Nyanza Provincial General hospital
RIDD= Respiratory Infectious Disease Department

4.4.6 Characteristics of patients who died within 7 days after onset of respiratory HAI and those who died after 7 days of onset of respiratory HAI

4.4.6.1 Comparison between patients that died within 7days of respiratory HAI and those who died after 7 days of getting respiratory HAI by demographic characteristics

Table 4.15 shows characteristics of patients that died within 7days of respiratory HAI and those who died after 7 days among 155 patients with at least 1 HAI. Of the 155 patients with at least one case of respiratory HAI, 41/155 (26.5%) died, of which 18/41 (43.9%) deaths occurred within 7days of a new respiratory HAI case and 23/41 (56.1%) deaths occurred >7days after a new respiratory HAI case. Of the, 16/155 (10.3%) respiratory HAI patients >50 years old, 9/16 (56.3%) died in the hospital; of those, 6/9 (37.5%) died within 7days of having a respiratory HAI, while 3/9 (18.8%) deaths occurred >7days after having a respiratory HAI.

The proportion of patients who died within 7 days among patients with at least 1 episode of respiratory HAI was highest in the ICUs 14/22 (63.6%), followed by medical wards 2/8 (25.0%) and paediatric wards 2/9 (22.2%, $p>0.05$). Few patients who had at least one pathogen identified died within 7days 3/8 (37.5%) compared with patients who did not have any virus identified 15/33 (45.5%, $p>0.05$).

Table 4.15. Selected characteristics of patients that died within 7days of respiratory HAI and who died after 7days among 155 patients with at least 1 HAI case

Variable	Total (n=155)	Died<7days (n=18, 11.6%)		Died ≥7days (23, 14.8%)		Died all (n=41,26.5)		P value
Sex	**n(%)**	**n**	**%**	**n**	**%**	**n**	**%**	
Male	98(63.2)	7	30.4	16	69.6	23	56.1	P=0.0495*
Female	57(36.8)	11	61.1	7	38.9	18	43.9	
Age, Years								
1(<5YRS)	74(47.7)	4	40.0	6	60.0	10	24.4	
2(5-<18)YRS	13(8.4)	0	0.0	3	23.1	3	7.3	P=0.3587
3(18-<35YRS)	33(21.3)	4	12.1	6	18.2	10	24.4	
4(35-<50YRS)	19(12.3)	4	21.1	5	26.3	9	22.0	
5(≥50YRS)	16(10.3)	6	37.5	3	18.8	9	22.0	
Hospital								
KNH	90(58.1)	16	43.2	21	56.8	37	90.2	P=0.4916
MDH	30(19.4)	1	100.0	0	0.0	1	2.4	
NNPGH	35(22.6)	1	33.3	2	66.7	3	7.3	
Ward Type								
Burns unit	4(2.6)	0	0	0	0	0	0.0	
Eye	3(1.9)	0	0.0	1	100.0	1	2.4	
ENT	4(2.6)	0	0	0	0	0	0.0	
ICU	40(25.8)	14	63.6	8	36.4	22	53.7	P=0.0945
Medical	21(13.6)	2	25.0	6	75.0	8	19.5	
Pediatrics	75(48.4)	2	22.2	7	77.8	9	22.0	
RIDD	4(2.6)	0	0.0	1	100.0	1	2.4	
Surgical	4(2.6)	0	0	0	0	0	0.0	
>12 hrs per day	81(52.3)	2	18.2	9	81.8	11	26.8	

Key:

*P < 0.05;
‡Insufficient data to make the comparison
ICU=Intensive Care Unit
RIDD= Respiratory Infectious Disease Department
NNPGH=New Nyanza Provincial General hospital
HAI=Healthcare Associated Infection
KNH=Kenyatta National Hospital
MDH=Mbagathi District Hospital
ENT=Ear, Nose and Throat ward

4.4.6.2 Comparison between patients that died within 7days of respiratory HAI and those who died after 7 days of getting respiratory HAI by type of virus identified

Table 4.16 shows comparison between patients that died with seven days of acquiring respiratory HAI and those who died after seven days of acquiring respiratory HAI by the laboratory confirmed virus identified in that specific patient. There were no difference statistically ($p>0.05$) between patients who developed respiratory HAI and died with seven days and those who died after seven days in regards to type of virus identified or if the patient had multiple viruses identified.

Table 4.16. Selected characteristics of patients that died within 7days of respiratory HAI and who died after 7days among 155 patients with at least 1 HAI case

Variable	Total (n=155)	Died<7days (n=18, 11.6%)		Died ≥7days (23, 14.8%)		Died all (n=41,26.5)		P value
	n(%)	n	%	n	%	n	%	
Lab confirmed respiratory HAI								
Absent	99 (63.9)	15	45.5	18	54.5	33	80.5	P=0.1654
Present	56 (36.1)	3	37.5	5	62.5	8	19.5	
Multiple virus								
0	99 (63.9)	15	45.5	18	54.5	33	80.5	
1	39 (25.2)	2	50.0	2	50.0	4	9.8	P=0.7143
2	13 (8.4)	1	25.0	3	75.0	4	9.8	
3	3 (1.9)	0	0	0	0	0	0.0	
4	1 (0.65)	0	0	0	0	0	0.0	
Type of virus								
Influenza	16 (10.3)	0	0	0	0	0	0.0	‡
FLU A	12 (7.7)	0	0	0	0	0	0.0	‡
FLU B	5 (3.2)	0	0	0	0	0	0.0	‡
ADENO	15 (9.7)	1	50.0	1	50.0	2	4.9	P=0.8586
RSV	21 (13.6)	2	40.0	3	60.0	5	12.2	P=0.8512
HMPV	3 (1.9)	0	0	0	0	0	0.0	‡
PIV 1	4 (2.6)	0	0.0	1	100.0	1	2.4	P=0.3704
PIV 2	2 (1.3)	0	0	0	0	0	0.0	‡
PIV 3	17 (10.97)	1	25.0	3	75.0	4	9.8	P=0.4226
Total Virus								
0	99 (63.9)	15	45.5	18	54.5	33	80.5	P=0.7143
1	38 (24.5)	2	50.0	2	50.0	4	9.8	
2	14 (9.0)	1	25.0	3	75.0	4	9.8	
3	3 (1.9)	0	0.0	0	0	0	0.0	‡
4	1 (0.7)	0	0.0	0	0	0	0.0	‡
How often friends and family are with patient in the hospital								
<1hr per day	39 (25.2)	1	33.3	2	66.7	3	7.3	
1-5 hrs per day	5 (3.2)	13	59.1	9	40.9	22	53.7	P=0.1589
6-12hrs	1 (0.7)	0	0	0	0	0	0.0	
>12 hrs per day	81 (52.3)	2	18.2	9	81.8	11	26.8	

Key:

*P < 0.05;

‡Insufficient data to make the comparison

4.4.7 Hand hygiene compliance rate amongst the Healthcare workers

Hand hygiene adherence results stratified by hospital, ward type and healthcare worker type are shown in Table 4.17. A total of 4140 observations were collected from 536 audits during this period. The observations were from all the healthcare workers in the surveillance wards. The participation rate was 50.9% (95% CI, 49.3-52.4%) for the nurses, 24.9% (95% CI, 23.6-26.3%) for Medical Officers, 13.1% (95% CI, 12.1-14.1%) for Clinical Officers, 4.7% (95% CI, 4.1-5.4%) for students,5.4% (95% CI, 4.8-6.2%) for technicians and 1.1% (95% CI, 0.8-1.5%) for others. Overall, the hand hygiene compliance rate was 35.3% (95% CI, 33.9-36.8%) and varied significantly between hospitals ($P<0.05$),ward type and month. The highest observed compliance rate was in KNH 40.2% (95% CI, 38.4-42.1%) and the lowest in MDH 5.0% (95% CI, 3.5-7.2%).

In the ward type, the highest compliance was in the burns unit 53.1% (95% CI, 48.2-57.9%) and the lowest in the paediatric wards 24.8% (95% CI, 21.7-28.2%) . There was significant difference in the hand hygiene compliance between the months. The highest observed compliance was in the month of November (3^{rd} month of study), 48.9% (95% CI, 44.8-53.1%), and the lowest in the month of May (9^{th} month of study), 17.7% (95% CI, 13.8-22.5%).The observed compliance rate among the various health care providers, was also significantly different ($P<0.05$). The highest compliance was among nurses, 44.0% (95% CI, 41.9-46.1%) and the lowest among the non-clinical staff 13.6% (95% CI, 6.4-26.7%).

Table 4.17. Hand hygiene compliance rate stratified by hospital, ward type and healthcare worker type, Sep 2009-July 2010

Hospital	Observation	Success		Odds Ratio 95% CI	P-Value
NNPGH	913	355	38.9%	Reference	
KNH	2686	1081	40.2%	1.6(0.61-3.99)	0.8955
MDH	541	27	5.0%	2.7(0.79-8.98)	0.123
Total	**4140**	**1463**	**35.3%**	<.0001	
Discipline					
Others	44	6	13.6%	Reference	
CO	540	101	18.7%	0.6(0.15-2.03)	0.004*
MO	1031	302	29.3%	0.9(0.30-2.98)	0.0196*
Nurse	2104	925	44.0%	3.9(1.27-11.65	<0.0001
Student	193	81	42.0%	3.9(1.03-14.48)	0.0184*
Technician**	225	48	21.3%	2.4(0.64-9.43)	0.2845
Total	**4137**	**1463**	**35.4%**		
Ward Type					
Surgical	528	173	32.8%	Reference	
Burn	403	214	53.1%	2.2(0.90-5.18)	0.1828
ENT	326	142	43.6%	0.8(0.31-2.29	0.1653
EYE	230	92	40.0%	2.8(0.91-8.73)	0.1275
ICU	460	236	51.3%	2.3(1.48-7.53)	0.002*
Medical	1131	308	27.2%	1.3(0.63-2.81)	0.7736
Paediatrics	677	168	24.8%	0.91(0.42-1.97)	0.0804
RIDD	385	130	33.8%	0.83(0.39-1.79)	0.0436*
Total	**4140**	**1463**	**35.7%**	<.0001	

Key:

*P < 0.05

**Technician= occupation therapist, physiotherapist, lab technician

ICU=Intensive Care Unit

RIDD= Respiratory Infectious Disease Department

NNPGH=New Nyanza Provincial General hospital

HAI=Healthcare Associated Infection

KNH=Kenyatta National Hospital

MDH=Mbagathi District Hospital

ENT=Ear, Nose and Throat ward

4.4.7.1 Hand hygiene compliance rate versus respiratory HAI over study period

Figure 4.3 shows, hand hygiene compliance rate was negatively co-related with respiratory HAI rates per 100 admissions. No significant changes were observed, as the pearson correlation of hand hygine compliance in relation to respiratory HAI over the time was (r=-0.2067, P>0.05).

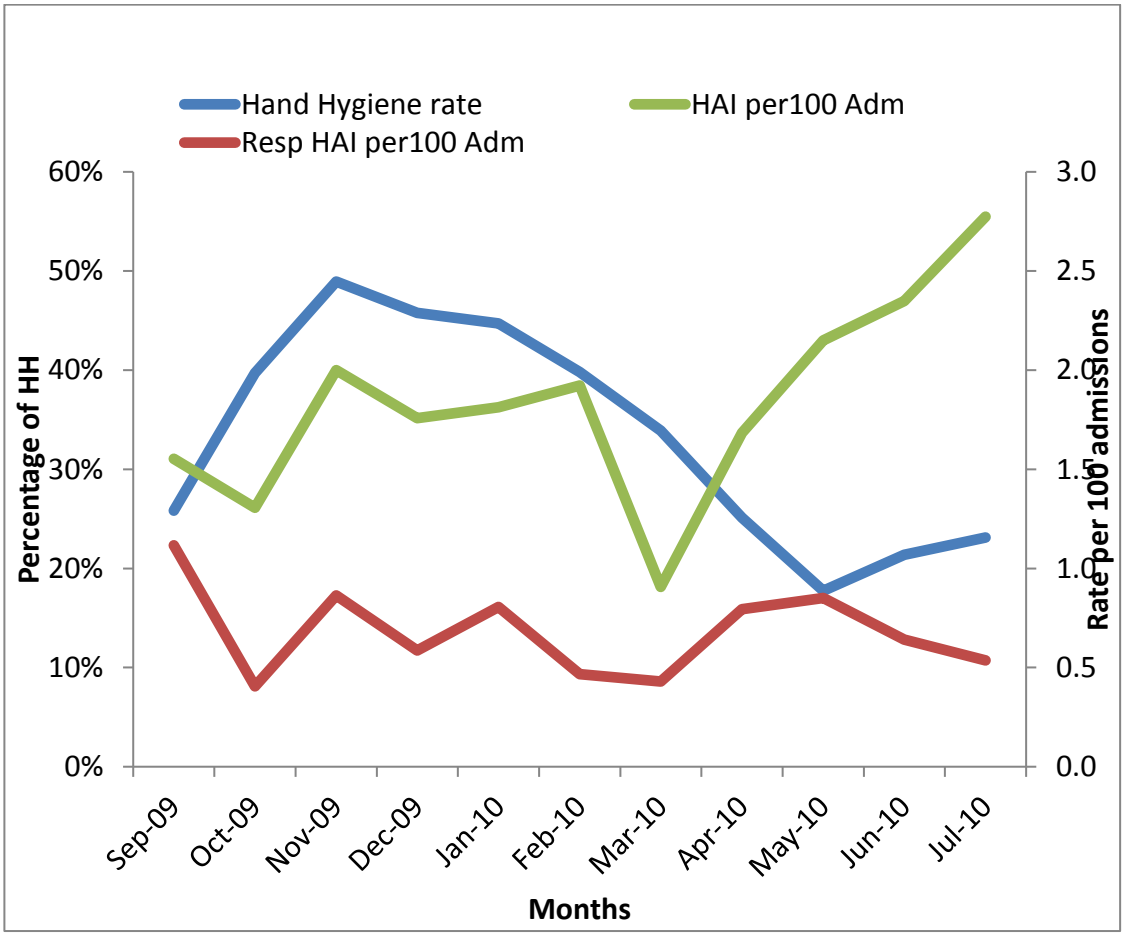

Figure 4.3: Hand hygiene adherence rate amongst the Healthcare workers Versus HAI rates

CHAPTER FIVE

5.0 DISCUSSION

5.1 The incidence of respiratory HAIs in selected hospitals in Kenya

In this study, the overall incidence of respiratory HAI rate was 0.8 per 1000 patient days. Although there are few comparable studies documenting incidence rates of respiratory HAIs in similar settings, the estimates of incidence of 1.1 infections per 1000 patient days in paediatric wards in Kenya are consistent with a study from Canada that reported an incidence of 0.29-1.50 respiratory HAIs per 1000 patient days in the paediatric hospitals (Vayalumkal *et al.*, 2009). These findings are also similar to respiratory HAI incidence rates of 0.79 per 1000 patient days reported in Germany in 2004 for children less than three years old (Forster *et al.*, 2004).

The incidence of respiratory HAI was highest in ICUs, followed by the paediatric wards. Nearly all of the virus-positive Respiratory HAI cases occurred in patients less than 18 years of age, suggesting that virus transmission among infant and young patients is an important infection control priority. Although virus positivity among respiratory HAI patients in ICUs was lower than in the paediatric wards, the high overall incidence of respiratory HAIs in ICUs suggests that both the specificity of the respiratory HAI case definition and the possibility of bacterial respiratory HAI be further evaluated in ICU patients. The incidence of respiratory HAI generated by this study is not easily comparable with data from other countries; most report healthcare associated pneumonias or device associated pneumonias as opposed to more general respiratory infection.

In addition, this study reports general viral respiratory HAI, as opposed to specific viruses causing respiratory HAI. On the other hand, most studies focus on specific patients' populations, like pediatrics, neonates or ICU as opposed to more general patients' populations.

There are some notable differences between the findings of this study and other published studies on respiratory HAIs. A study conducted in Bangladesh in 2011 found the incidence of respiratory HAI to be 6.1 per 1000 patient days (Gurley *et al.*, 2010), which is about 8-fold higher than what is documented in Kenya. This difference could be caused by differences in data collection strategies; in Bangladesh, staff gathered data on all respiratory HAIs by visiting wards daily, whereas in Kenya data on all respiratory HAIs was collected by visiting the wards twice per week. It is possible that rates of respiratory HAI are significantly higher in Bangladesh than in Kenya because of hospital crowding or possibly because of differences in infection control practices.

In Bangladesh, family members provide the majority of the nursing care in hospitals. Family caregivers (FCGs) are present on the wards 24 hours a day (Hadley and Roques, 2007) and on average, two FCGs (Blum *et al.*, 2009) accompany each patient at any given time in hospital, outnumbering all other persons on the wards. Their social norms demand that family members maintain close contact with sick patients (Blum *et al.*, 2009). In contrast to nurses in Bangladesh, who spend only about 5% of their time in direct patient care giving activities (Hadley and Roques, 2007), 75% of the care that the FCGs provide to patients involves close contact with patients, including sharing the same food, cleaning their secretions, and sleeping in the same bed (Islam *et al.*, 2014).

In Kenya, FCGs are not allowed to stay with the patient except to vising them during vising hours, except in very rare cases especially in pediatric wards where mothers stay with their babies, only those below five years. The majority of care-giving activities are provided by the nursing staff. In addition, during this study, health education sessions to health care providers were introduced to improve infection control practices (hand hygiene, cohorting). Although the impact of these health education sessions was not evaluated formally, it is possible that the education sessions led to improvements in infection control in the three hospitals, which could explain why our reported respiratory HAI rates are lower than those reported in Bangladesh. When education sessions were done the hand hygiene rates improved and the rates of HAI declined (Figure 4.2).

On the other hand, using our preliminary data, we helped the ministry of health develop national infection control policy and guidelines which were also implemented during the last half of the study (MOH, 2010).

5.2 Viral pathogens associated with respiratory HAI in selected hospitals in Kenya

In this study, there were 155 patients identified with respiratory HAI. Of these 131 (84.5%) had their nasopharyngeal and oropharyngeal swabs taken and tested for presence of a virus. Fifty six (42.7%) of the samples tested had at least one viral pathogen identified. When we compared patients from whom specimens were collected, with patients from whom specimens were not collected, there was no significant differences in age, sex, ward type or hospital noted. Reasons for not collecting specimens included refusal by the patient or their guardian or inability to obtain the sample, like patient being on oxygen mask or having severe difficulty in breathing.

In this study 34.8% of samples were positive for at least one viral pathogen which was in contrast to findings of a recent study of acute respiratory illness in older children and adults in rural Western Kenya, that documented 58% positivity for at least one viral pathogen amongst the inpatients (Feikin *et al.*, 2012). However, the distribution of various viruses identified by Feikin *et al* (2010) was similar to this study; influenza virus A (10% compared with 9.3%), influenza virus B (3.0% compared with 3.8% (Table 4.6), and RSV (12% compared with 15.8%) (Feikin *et al.*, 2012).

Another study reported similar rates of viral pathogens among infants and children at a rural hospital in Coast region of Kenya (56% of patients with respiratory infection had respiratory specimens that were positive for at least 1 virus), a slightly lower percentage of specimens' positive for influenza virus A (5.8%), and a higher percentage of RSV-positive samples of 34% (Berkley *et al.*, 2010).

In this study nearly all the virus-positive healthcare associated respiratory cases occurred in patients less than 18 years of age, suggesting that virus transmission among paediatric population is important infection control priority.

Respiratory Syncytial Virus was the most commonly detected virus reported in this study. Similarly Feikin *et al* (2012) documented RSV was associated with ARI among inpatients, but not outpatients, which explains the role RSV plays in respiratory HAI (Feikin *et al.*, 2012) . Respiratory Syncytial Virus has been shown to cause respiratory HAI outbreak in NICU (Silva Cde *et al.*, 2012). It has also been shown to be the leading cause of hospitalisation of ARI in Kenyan children (Berkley *et al.*, 2010). Nosocomial transmission of RSV frequently follows community outbreaks (Lavergne *et al.*, 2011). Influenza and Para-influenza 3 was the second most common detected virus.

Influenza poses a serious peril to hospitalized patients in both low and high resource countries (Katz *et al.*, 2014; Ortiz *et al.*, 2014). Hospitals in low income countries like Kenya are likely at increased risk for influenza transmission because factors associated with influenza transmission are common, including crowded conditions (patients sharing bed), no restriction on the number of visitors per patient at single moment, and lack of routine infection control practices. These hospitals were regularly overstrained with patients. Wards with high patients per nurse ratio were associated with increased risk of respiratory HAI. In all three hospitals paediatric wards had the highest median number of patients per nurse (range 9.1 to 18.9). World Health Organization, and Association of American Nurses (ANA) recommends a ratio of 1 to 6 (ANA, 2010). Due to this high ratio, patients are cared for by relatives, who spend most of the time with the patients and providing some nursing care because of the shortage of staff. These patient caregivers rarely maintain adequate hand and respiratory hygiene, partly because hand hygiene facilities are inadequate (Rimi *et al.*, 2014).

5.3 Risk factors for Respiratory Viral HAI in selected hospitals in Kenya

A knowledge of risk factors is specifically significant to support stratification of respiratory HAI rates and implement adequate infection control measures. In this study, 41 of 56 (73.2%) patients less than five years had respiratory HAI. This is similar to other studies that have shown that respiratory viral HAI rates vary by age, ward type or service (Goldwater and Martin, 1991). Infection rates commonly are associated inversely with age: the highest rate being described in children less than five years old (Seto, 2007).

Some studies in which less than 9% of patients have been younger than a year old have been reported (Goldwater and Martin, 1991). The methodology used in the study, availability of laboratory capacity for virology services may explain these discrepancies (Jarvis *et al.*, 1985; Goldwater and Martin, 1991).

In multivariate analysis, ward type, having a central catheter, having urinary tract infections (UTI), family or friend staying with the patient for >6hours and sex of the patient were shown to be associated with a significant risk of respiratory HAI. Type of the ward, especially the ICU was associated with high rate of respiratory HAI. The Canadian study, documented that patients admitted in the ICU were at higher risk of respiratory HAI (Vayalumkal *et al.*, 2009). One primary risk factor for respiratory HAI is the use of respirators, which were present in the hospitals where both the Canadian and German studies were conducted; respirators were not commonly used in our study sites, only 2% of the subjects were on respirators (Forster *et al.*, 2004; Vayalumkal *et al.*, 2009). Although this difference complicates the comparison of the current findings with the two studies, this still provide baseline estimates that have some consistency with respiratory HAI rates observed elsewhere.

The cause of respiratory viral HAI is mainly infected patients on the same ward, but staff and visitors may also play a role, although this study did not investigate the role played by the visitors and healthcare workers.

Other causes may include design of the ward, sharing of the bed or room, hand hygiene (Ellingson *et al.*, 2014; Merk *et al.*, 2014) of the staff and other infection control practices, like standard precautions, respiratory hygiene and use of personal protective equipment by the staff.

The staffs were not monitored clinically or virologically, to ascertain the extent to which they may have contributed to the transmission of respiratory viruses in this study. However, hand hygiene among the staff was investigated, because hand hygiene has been documented to prevent and reduce the transmission of respiratory viruses in healthcare settings and the community (Leclair *et al.*, 1987; Boyce *et al.*, 2002b)

The amount of time that visitors stayed with the patient was associated with risk of respiratory HAI. Those who had the visitors staying more than 6hours with the patients were more at risk of developing respiratory HAI. Different studies and settings have shown visitors as a risk factor associated with respiratory HAI ((Macartney *et al.*, 2000)). In a study done in Bangladesh, why Bangladeshi nurses avoid 'nursing': social and structural factors on the hospitals wards showed that where family members provided patient hands-on-care was protective to HAI (Hadley, Blum, *et al.*, 2007).

Respiratory HAI not only cause obvious morbidity but also increases hospital stay with consequent cost implications (Graves, 2004; Jackson *et al.*, 2011). In view of this, further strategies to reduce respiratory HAI should be considered, for example patient cohorting and screening. On deciding the additional strategies to invest in, these should be informed by the expected changes to both cost and health outcomes, and only efficient strategies should be used (Graves *et al.*, 2007). Respiratory viruses are spread by direct inhalation of large droplets and by direct contacts of hands and fomites (Falsey *et al.*, 2005; Groothuis *et al.*, 2008). Use of personal protective equipment (PPE) such as masks, gowns by the staff has been reported (Muller and McGeer, 2006), to reduce respiratory HAIs.

In addition, isolation, cohorting of infected patients and cohorting of staff to infected patients have been shown to reduce the spread of respiratory virus infection. In the study by Hall, (1978) barrier nursing involving strict hand hygiene and the use of gowns was routinely practiced (Hall *et al.*, 1978; Jefferson *et al.*, 2011).

In this study, over half of the patients identified to have respiratory HAI died while they were in hospital, and nearly half of those deaths 36 (47.5%) occurred within seven days after the patient was found to have a respiratory HAI. Although, this study did not measure death attributable to respiratory HAI, death within seven days of diagnosis may serve as a proxy indicator (See *et al.*, 2013). The proportion of patients with respiratory HAI who died in this study is higher than that reported in similar studies, for example in a Canadian study (Vayalumkal *et al.*, 2009), 9% of febrile respiratory HAI cases died; in Bangladesh (Gurley *et al.*, 2010), 2% of respiratory Hai patients died. A study in USA, by Spaeder, *et al.* suggested that children with respiratory HAI were associated with increased mortality and they documented, 8% mortality of children with respiratory HAI (Spaeder and Fackler, 2011).

5.3.1 Hand hygiene among the health care workers

Hand hygiene plays a critical part in prevention of respiratory HAI (Allegranzi and Pittet, 2009). In a study done in Italy by Capretti *et al* (2008) documented a significant reduction in HAIs incidence from 4.1 to 1.2 per 1000 patient days ($p<0.05$) over a period of 18 months (Capretti *et al.*, 2008). During this study, the hand hygiene compliance rate among the health care workers in the hospitals was low (35.3%).

Proper hand hygiene among healthcare workers is critical to preventing the transmission of HAIs (Boyce *et al.*, 2002a). This level of compliance of hand hygiene among healthcare workers was less than that reported in developed countries (74%) (Moret *et al.*, 2004); however, it is higher than that reported in public secondary care hospitals in Kuwait (33.4%), Saudi Arabia (23.7%) , Spain (20%) or in an Italian long term care facility (17.5%) (Basurrah and Madani, 2006; Novoa *et al.*, 2007; Pan *et al.*, 2008; Al-Wazzan *et al.*, 2011; Abdella *et al.*, 2014). The reasons for low hand hygiene adherence include lack of running water, lack of functional sinks, distance of functional sinks, from the point of patient care, lack of efficient modes of hand drying, lack of infection control programs, lack of guidelines and policy on infection control (Kampf and Kramer, 2004).

In this study as the hand hygiene improved, the number of cases of HAIs per 100 admissions declined, but when the hand hygiene declined the HAI rates increased, although this was not statistically significant ($p>0.05$). In the first months of the study, (September 2009 to November 2009) the hand hygiene compliance rate was higher than the later months of the study (Fig 4.3). This is because at the early stages the health care workers were aware of the hand hygiene audits, which made them to improve their behaviour on hand hygiene. By the sixth month (February 2010) of the study, HCW had forgotten about the audit and the hand hygiene had started to decline, by ninth (May 2010) month hand hygiene adherence was less than 20% and HAI had increased to 2.1/100 admissions (Figure 4.3). These findings suggest that there is a logical and significant, association between hand hygiene and HAI.

This is confirms the considerable body of evidence that hand hygiene can reduce the risk of bacterial and viral hand contamination and prevent healthcare associated infections. This study adds evidence to a pattern of findings (Allegranzi, *et al*, 2009) suggesting that HAIs can be prevented by hand hygiene.

On contrary, respiratory HAI did not show a similar pattern like the general HAI. This could be partly because respiratory HAI can also be transmitted via airborne which requires respiratory cohorting of patients to prevent respiratory HAI. Some studies, have shown that neither the use of gowns, cohorting of patients, use of gloves and hand hygiene alone can lead to reduction of respiratory HAI due to respiratory syncytial virus (RSV) (Madge *et al.*, 1992; Lee *et al.*, 2012). Respiratory HAIs prevention is a combination of a number of factors, including wearing mask for those having respiratory infections and are attending to patients, Madge, (1992).

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

From the study the following conclusions were made;

1. The overall incidence of respiratory HAI in this study was 0.8 infections per 1000 patient-day's rates which are similar to those documented by other studies.
2. The three most common viral pathogens associated with respiratory HAI were RSV (15.8%), influenza (12.8%) and parainfluenza 3(12.8%), 12.8% patients had co-infections.
3. The risk factors for respiratory viral HAI amongst inpatients in the three hospitals in Kenya were:
    a. Poor hand hygiene compliance rate 35.3%
    b. ward type-paediatric
    c. Having a central line catheter
    d. Having urinary tract infections (UTI)
    e. Family or friend staying with the patient for >6hours and sex of the patient were shown to be associated with a significant risk of respiratory HAI.
4. The study showed that respiratory HAI occurred consistently throughout the year without any clear seasonal trends.

6.2 Recommendations

From the study the following are the recommendations:

1. The three facilities should limit the number of hours a relative or friends stays with the patient in the ward. This should also include screening and exclusion of symptomatic visitors to control infections.
2. Introduction of influenza vaccine to staff and other members of the community at risk would minimize and improve risk of respiratory HAI transmissions.
3. Hospitals should have policies and guidelines that can enable them strengthen the infection control activities such as surveillance for HAIs and Hand hygiene monitoring.
4. Hospitals should have infection control committee to monitor and evaluate measures taken to prevent HAIs in the hospitals.

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Appendices

Appendix 1: Daily line list for patients hospitalized in surveillance wards

Please create a new entry for patients on the ward exhibiting thermal instability, or cough or sore throat. Always record date of onset and total number of patients on ward

Hospital: ☐KNH ☐New Nyanza PGH ☐Mbagathi D.H.**Surveillance Officer**: ___________________________

Date: _____________________**Ward**: ______________________**Total # Patients on Ward**: _______________________

Name	Age (M/Y)	Sex	Admit Date	Diagnosis on admission	Fever/ Hypothermia	Cough or Sore Throat
					Temp: ______Onset: ___/____/___	Onset: __/____/___
					Temp: ______Onset: ___/____/___	Onset: ___/____/__
					Temp: ______Onset: ___/____/___	Onset: ___/____/__
					Temp: ______Onset: ___/____/___	Onset: ___/____/__
					Temp: ______Onset: ___/____/___	Onset: ___/____/__
					Temp: ______Onset: ___/____/___	Onset: ___/____/__
					Temp: ______Onset: ___/____/___	Onset: ___/____/__
					Temp: ______Onset: ___/____/___	Onset: ___/____/__
					Temp: ______Onset: ___/____/___	Onset: ___/____/__
					Temp: ______Onset: ___/____/___	Onset: ___/____/__

Total # fever: ____________________

Total # fever + resp symptoms:

_____

Appendix 2: Suspected HAI patient report form

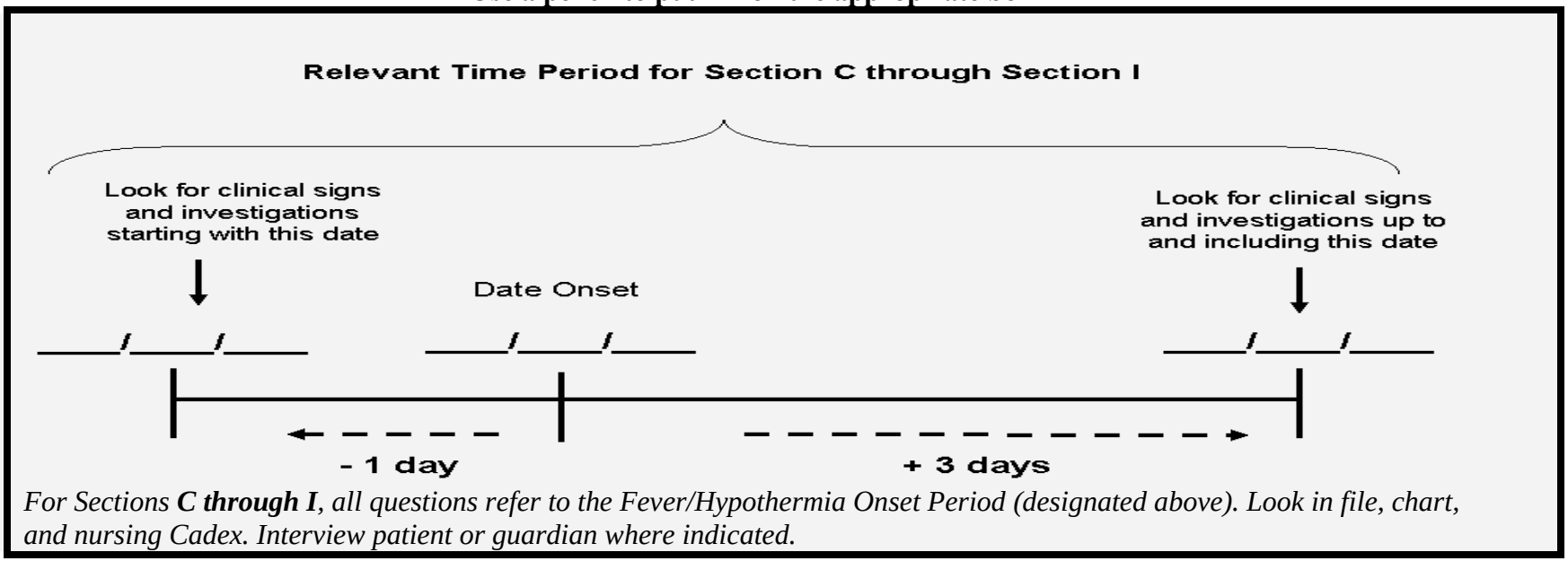
For Patients with New Onset Fever or Hypothermia

SECTION A: General Information

Num.	Question Prompt	Coding Category	Skip to
A1	Date of Report Form Initiation	▬ ▬/▬ ▬ ▬ ▬/▬ ▬ ▬ ▬ dd/Month/yyyy e.g. 21 Feb 2010	
A2	Surveillance Officer's Name	George❑ Jackson ❑ Kenneth❑ Martha ❑	
A3	Patient Initials		
A4	Patient IP Number*(if patient has more than two episodes of new fever add a letter to subsequent form e.g. 129822, 129822**a**, 129822**b**)*		
A5	Hospital name ***(Circle only one)***	KNH ❑ NNPGH ❑ MDH ❑	
A6	Type of Ward ***(Put 'X' on only one)***	Medical ❑ HDU-Paediatrics ❑ Paediatrics ❑ ICU ❑ Eye ❑ Neonate ICU ❑ Surgical ❑ Burns unit ❑ RIDD NT ❑	
A7	Age in Years. ***(List in months if patient is under 1 year of age).***	Age in Years |__|__| Age in months |__|__| *(If under one year)*	
A8	Sex ***(Circle only one)***	Male ❑ Female ❑	
A9	Admission Date ***(Indicate the date of admission per the clinician's notes)***	▬ ▬/▬ ▬ ▬ ▬/▬ ▬ ▬ ▬ *dd/Month/yyyy e.g. 21 Feb 2010*	
A10	Admitting Diagnoses ***(per clinician Admission note)***		

SECTION B: NEW ONSET OF FEVER/HYPOTHERMIA

Use a pencil to put 'X' on the appropriate box



*For Sections **C through I**, all questions refer to the Fever/Hypothermia Onset Period (designated above). Look in file, chart, and nursing Cadex. Interview patient or guardian where indicated.*

SECTION B: NEW ONSET OF FEVER/HYPOTHERMIA

Please fill in the timeline below: this represents the time period during which you will look for clinical signs and investigations to complete sections C through I

Num.	Question Prompt	Coding Category	Skip to
B1	Date of new onset of fever/hypothermia	▬▬/▬▬▬▬/▬▬▬▬ *dd/Month/yyyy e.g. 21 Feb 2010*	
B2	Max/min abnormal temperature on date of onset (Max temp= greater than or equal to 38 ◦C. Min temp= <35)	|__|__.__| ◦Celsius	
B3	Temperature on date of last recorded normal temperature	|__|__.__| ◦Celsius	
B4	Date of the last recorded normal temperature	▬▬/▬▬▬▬/▬▬▬▬ *dd/Month/yyyy e.g. 21 Feb 2010*	
B5	Working diagnosis <u>at time of</u> fever/hypothermia ***(per clinician notes)**:*		

SECTION C: RESPIRATORY INFECTION

(NOTE: look within -1/+3 days of onset—i.e. the time frame of interest)

Num.	Question Prompt	Coding Category	Skip
C1	Did the patient have a new onset cough? ***Obtain this information from file/ cardex, procedure form, vitals and ALSO (<u>interview</u> patient/guardian)***	Yes ❑ No ❑ Unable to obtain❑	
C2	Did patient have new onset sore throat? ***(<u>interview</u> patient)***	Yes ❑ No ❑ Unable to obtain❑	
C3	Did patient have any of the following: ***crackles***, ***rhonchi***, ***decreased breath sounds***, ***crepitus***	Yes ❑ No ❑	
C4	Was a chest X-ray taken or documented in plan?	Yes ❑ No ❑	→ C

C4a	**If "yes",** was there radiology report or clinician documentation in note stating that X-ray was consistent with: pneumonia, infiltrate, consolidation, air bronchograms, pneumatoceles?	Yes ❑ No ❑	
C5	Is the blood SO_2 (pulse oximetry) less than or equal to 90%?	Yes ❑ No ❑	
C6	For non-ventilated patients, was there a plan for or documentation of supplemental oxygen?	Yes ❑ No ❑ Unable to obtain❑	
C7	Was patient on a ventilator	Yes ❑ No ❑	→ C
C7a	Was an arterial blood gas obtained?	Yes ❑ No ❑	
C7b	Was the paO2 on the blood gas less than lower limits of normal?	Yes ❑ No ❑	
C7c	Was the "O_2 i/m or %" (as recorded on Kenyatta vital forms) or Oxygen supplied by vent (as reported at New Nyanza) > 40%?	Yes ❑ No ❑	
C8	Was a sputum culture (for non-vented patients) or tracheal culture (for vented) documented in plan or obtained?	Yes ❑ No ❑	→ C
C8a	Was culture positive for any organism	Yes ❑ No ❑	→ C
C8b	If yes Specify organism identified		
C8c	Specify amount of growth	Light ❑ Moderate❑ Heavy ❑Unknown❑	
C9	In a patient who did not have respiratory symptoms on admission, did any of the following develop during the time frame of interest: **"pneumonia", "upper respiratory tract infection (URTI/URI)", "productive sputum?"** *Only tick "yes" if these words were used during the time period of interest. NO clinical judgment.*	Yes ❑ No ❑ Not applicable ❑ *(this should only be ticked if patient was admitted with a respiratory infection)*	
C10	Does the patient meet criteria for swabbing?	Yes ❑ No ❑	→ D
C10a	Was patient swabbed?	Yes ❑ No ❑	→ D
C10b	Type of swab?	NP ❑ OP ❑Endotracheal ❑	→ D
C10c	Why was patient <u>not</u> swabbed?	Refused ❑ Unable to obtain ❑Other (specify) ❑	

SECTION D: URINARY TRACT INFECTION

(NOTE: look within -1/+3 days of onset, i.e. the time frame of interest)

Num.	Question Prompt	Coding Category	Skip
D1	Was a Urine Analysis (UA) documented in plan?	Yes ❑ No ❑	→ D
D2	Was a UA obtained	Yes ❑ No ❑	→ D
D2a	Was leukocyte positive?	Yes ❑ No ❑	
D2b	Was nitrite positive?	Yes ❑ No ❑ Unknown ❑	
D2c	Were pus cells positive?	Yes ❑ No ❑ Unknown ❑	
D2d	Was culture positive for any organism	Yes ❑ No ❑ Unknown ❑	→ D
D2e	If yes Specify organism		
D2f	Specify amount of growth	Light ❑ Moderate ❑ Heavy ❑ Unknown ❑	
D3	If a patient did not have symptoms of urinary tract infection (UTI) on admission, did any of the following develop during the time frame of interest: **"UTI", "cystitis", "pyelonephritis?"** Only tick yes if these words were used, NO clinical judgment.	Yes ❑No ❑ Not applicable❑	

SECTION E: BLOODSTREAM INFECTION

(NOTE: look within -1/+3 days of onset, i.e. the time frame of interest)

Num.	Question Prompt	Coding Category	Skip
E1	Was blood culture documented in plan?	Yes ❑ No ❑	 → E
E2	Was blood culture obtained?	Yes ❑ No ❑	 → E
E2a	Was culture positive for any bacterial or fungal organism?	Yes ❑ No ❑ Unknown ❑	 → E → E
E2b	If yes Specify organism		
E3	In a patient who did not have a bloodstream infection at admission, did bloodstream infection (i.e. positive blood culture) develop during the time frame of interest?	Yes ❑ No ❑ Not applicable ❑	

SECTION F: WOUND OR SURGICAL SITE INFECTION

(NOTE: look within -1/+3 days of onset, i.e. the time frame of interest)

Num.	Question Prompt	Coding Category	Ski
F1	Was a wound culture documented in plan?	Yes ❑No ❑	→
F2	Was wound culture obtained	Yes ❑No ❑	→
F2a	Was culture positive for any organism	Yes ❑No ❑ Unknown ❑	→
F2b	If yes Specify organism identified		
F2c	Specify amount of growth	Light ❑ Moderate ❑ Heavy❑Unknown ❑	
F3	If a patient did not have symptoms of wound infection on admission, did any of the following develop during the time frame of interest: **abscess, wound infection, surgical site infection, pus or drainage from wound**? ***Only tick "yes" if these words were used during the time frame of interest, no clinical judgment.***	Yes ❑ No ❑ Not applicable ❑	

SECTION G: DIARRHOEA

(NOTE: look within -1/+3 days of onset, i.e. the time frame of interest)

Num.	Question Prompt	Coding Category	Ski
G1	Was stool microscopy or culture or O/C (i.e. ova and cysts) documented in plan?	Yes ❑No ❑	→
G2	Was stool microscopy, or O/C or culture obtained	Yes ❑No ❑	→
G2a	Were there positive pus cells?	Yes ❑ No ❑ Unknown ❑	
G2b	Was an organism detected?	Yes ❑ No ❑ Unknown ❑ *(not documented in)*	
G2c	Specify organism		
G3	Was cholera swab positive?	Yes ❑ No ❑ Not applicable ❑	
G4	Was suspicion for hepatitis A documented?	Yes ❑ No ❑ Not applicable ❑	
G5	Was Hepatitis A antibody obtained?	Yes ❑No ❑	→
G5a	If yes, was the Hepatitis A antibody result positive?	Yes ❑ No ❑	
G6	If a patient did not have diarrhea on admission, did diarrhoea develop during the time frame of concern **(Interview Patient)?**	Yes ❑ No ❑ Not applicable ❑ *(NA should only be ticked if patient was admitted with diarrhoea)*	

SECTION H: CSF INFECTION

(NOTE: look within -1/+3 days of onset, i.e. time frame of concern)

Num.	Question Prompt	Coding Category	Ski
H1	Was lumbar puncture (LP) documented in plan?	Yes ❑No ❑	→
H2	Was cerebrospinal fluid (CSF) obtained?	Yes ❑No ❑	→
H2a	What was the cell count? (Write "unknown" if this is not recorded.)	Yes❑ No❑ Unknown ❑ *(not documented in report)*	
H2b	Was India Ink stain positive?	Yes ❑ No ❑ Unknown ❑ *(not documented in report)*	
H2c	Was Ziehl Nielsen (ZN) positive?	Yes ❑ No ❑ Unknown ❑ *(not documented in report)*	
H2d	Did the gram stain show fungus or bacilli?	Yes ❑ No ❑ Unknown ❑ *(not documented in report)*	
H2e	Did the CSF show acid fast bacteria (AFB/AAFB)?	Yes ❑ No ❑ Unknown ❑ *(not documented in report)*	→
H2f	Was culture positive for any organism	Yes ❑ No ❑ Unknown ❑ *(not documented in report)*	
H2g	If yes Specify organism identified		
H2h	Specify amount of growth	Light ❑ Moderate ❑ Heavy ❑ Unknown ❑	
H3	In a patient who did not have symptoms of meningitis at admission, did meningitis develop during the time frame of interest?	Yes ❑No ❑ Not applicable ❑ *(This should only be ticked if patient was admitted with meningitis)*	

SECTION I: OTHER INFECTIONS AND NON-INFECTIOUS CAUSES OF FEVER

(NOTE: look within -1/+3 days of onset, i.e. time frame of concern)

Num.	Question Prompt	Coding Category	Ski
I1	Was suspicion for extra pulmonary TB documented?	Yes ❑ No ❑	
I2	Was suspicion for PCP documented?	Yes ❑ No ❑	
I3	Was a Malaria and parasite blood smear (BS for MPS) documented in plan?	Yes ❑ No ❑	
I4	Was a malaria and parasite blood smear (BS for MPS) obtained?	Yes ❑No ❑	→
I4a	If "yes" to I4, was smear positive?	Yes ❑ No❑ Unknown ❑ *(not documented in report)*	
I5	Was Brucella titre documented in plan?	Yes ❑ No ❑	
I6	Was Brucella titre obtained?	Yes ❑ No ❑	→
I6a	What was the result		
I7	Was a Widal test for typhoid fever documented in plan?	Yes ❑ No ❑	
I8	Was a Widal titre obtained	Yes ❑No ❑ Unknown ❑ *(not documented in report)*	→
I8a	What was result		
I9	Was the complete haemogram (i.e. CBC) obtained or documented in plan between one day before and three days after the onset of fever/ hypothermia?	Yes ❑ No ❑	→
I9a	If "yes" to I9, was the White Blood Cell count above the upper limit of normal	Yes ❑ No ❑ Unknown ❑ *(this should only be ticked if no reference range is given for normal WBC range)*	

End of questions that deal with the time frame of interest. The below questions each ask about different time periods.
Please read carefully: SECTION J: PATIENT PROCEDURES AND MANAGEMENT
(IMPORTANT: time periods differ in this period, so read carefully)

Num.	Question Prompt	Coding Category	Ski
J1	Did patient have surgery within the 2 days prior to fever/hypothermia onset (this includes the day of the fever/ hypothermia)?	Yes ❑ No ❑	
J2	Was patient on anti-pyretics on the day of or the day prior to fever/hypothermia onset? *(only Include the following: PCM, Paracetamol, Perfalgan, Pacimol, Perocet, Acetaminophen)*	Yes ❑ No ❑	
J3	Patient on steroids within the 2 days prior to fever/hypothermia onset? *(only Include Prednisone/Prednisolone, IV Hydrocortisone, IV Dexamethasone)*	Yes ❑ No ❑	
J4	Was patient **started** on antibiotics on the day of, or in the 2 days after fever/hypothermia onset? Note: This includes flagyl. It does not include prophylactic cotrimoxaole. It does include treatment dose of cotrimoxazole. It does not include albendazole or TB medications or malaria medications.	Yes ❑ No ❑	
J5	Was patient on anti-TB treatment any time in hospitalization?	Yes ❑ No ❑ Unknown ❑	
J6	Did patient have central line in place within 2 days of fever/ hypothermia onset? **(look at patient)**	Yes ❑No ❑	
J7	Was patient admitted because of burns?	Yes ❑No ❑	
J8	Did patient have a branula /IV in place within 2 days of fever/hypothermia onset? **(look at patient)**	Yes ❑No ❑ Unknown ❑	
J9	Was there mention of head trauma **in admission note**?	Yes ❑No ❑	
J10	Was there mention of haemorrhage/bleeding in brain **in admission note**?	Yes ❑No ❑	
J11	Did patient receive blood transfusion **on the day of** fever/ hypothermia onset?	Yes ❑No ❑	
J12	Any other comments:	Yes ❑No ❑	

SECTION K: PRIOR HOSPITALIZATION

Num.	Question Prompt	Coding Category	Ski
K1	Was there any documentation of a previous hospitalization to any hospital in the last month?	Yes ❑ No ❑	
K2	Per patient, relative, or guardian interview, was patient admitted to any hospital one month prior to current admission? **(Interview patient/ family)**	Yes ❑ No ❑ Unknown ❑	
K3	Has patient been cared for by a friend or family member while hospitalized? (**Interview patient/ family)**	Yes ❑ No ❑ Unknown ❑	
K3a	***If "yes"*** how often are friends or family with the patient at the hospital?	<1hr per day ❑ 1-5 hrs per day ❑ 6-12 hr per day ❑ >12 hrs per day ❑ Unknown ❑	

Section L: Outcome

Num.	Question Prompt	Coding Category	Ski
L1	For what reason did patient leave the hospital	Discharged (left) ❑ Absconded ❑ Referred ❑ Death ❑ Transferred ❑ *(out of ICU or to another ward or to another hospital)*	
L2	Indicate the day of outcome	__/____/____ *dd/Month/yyyy e.g. 21 Feb 2010*	

Appendix 3: List of patients with suspected HAI (sHAI) that need to be followed for outcome
Hospital: ❑ KNH ❑ New Nyanza PGH ❑ Mbagathi D.H. **Surveillance Officer**:_____

Ward	Patient Name	Age	Sex	Admit Date	Type of SHAI	Outcome

Appendix 4: Respiratory HAI sampling and laboratory analysis

Specimen collection:

Oropharyngeal and nasopharygeal swabs were be collected by the HAI surveillance officer. The Oropharyngeal and nasopharygeal swab was collected with a dacron-tipped plastic-shafted swab rubbed against the posterior pharynx and tonsils. The sample was immediately placed into a cryovial with viral transport media. Samples were maintained at 4^{o} C until it can be sent to the CDC/KEMRI-IEIP laboratory in Nairobi of Kisumu for testing. Specimens was packed in cold boxes and transported to CDC laboratories by either CDC vehicles or courier service.

Specimen processing:

All specimens were stored at KEMRI/CDC laboratories in Kisian or Nairobi. An aliquot of each respiratory specimen was be tested by real time RT-PCR for influenza virus, respiratory syncytial virus(RSV), human parainfluenzae virus, adenovirus, human metapneumovirus, *Chlamydia pneumoniae* and *Mycoplasma pneumoniae,*and *Legionella spp.* For quality control purposes, all positive results was be retested, and 7 % of negative samples was be randomly rested. There was be a laboratorian at CDC responsible for Quality Assurance in both the Nairobi and Kisian laboratories.

Appendix 5: Pathogen specific primers

Respiratory pathogen	Primer name	Sequence
Influenza A Virus		
	FLU AFORWARD	GAC CRA TCC TGT CAC CTC TGA C
	FLU A REVERSE	AGG GCA TTY TGG ACA AAK CGT CTA
	FLU A PROBE	TGC AGT CCT CGC TCA CTG GGC ACG
Influenza B Virus		
	FLU B FORWARD	TCC TCA ACT CAC TCT TCG AGC G
	FLU B REVERSE	CGG TGC TCT TGA CCA AAT TGG
	FLU B PROBE	CCA ATT CGA GCA GCT GAA ACT GCG GTG
AdenoVirus		
	ADENO FORWARD	GCC CCA GTG GTC TTA CAT GCA CAT C
	ADENO REVERSE	GCC ACG GTG GGG TTT CTA AAC TT
	ADENO PROBE	5'TG CAC CAG ACC CGG GCT CAG GTA CTC CGA3'
Respiratory Syncytial virus		
	RSV FORWARD	GGC AAA TAT GGA AAC ATA CGT GAA
	RSV REVERSE	TCT TTT TCT AGG ACA TTG TAY TGA ACA G
	RSV PROBE	5'CT GTG TAT GTG GAG CCT TCG TGA AGC T3'
Human Metapneumo Virus		
	hMPV FORWARD	CAA GTG TGA CAT TGC TGA YCT RAA
	hMPV REVERSE	ACT GCC GCA CAA CAT TTA GRA A
	hMPV PROBE	5'TG GCY GTY AGC TTC AGT CAA TTCAAC AGA 3'
ParaInfluenza Virus 1		
	PIV 1 FORWARD	AGT TGT CAA TGT CTT AAT CG TAT CAA T
	PIV 1 REVERSE	TCG GCA CCT AAG TAA TTT TGA GTT
	PIV 1 PROBE	5'AT AGG CCA AAG A''T'' T GTT GTC GAG ACT ATT CCA 3'
ParaInfluenza Virus 2		
	PIV 2 FORWARD	GCA TTT CCA ATC TAC AGG ACT ATG A
	PIV 2 REVERSE	ACC TCC TGG TAT AGC AGT GAC TGA AC
	PIV 2 PROBE	5'CC ATT TAC C''T''A AGT GAT GGA ATC AAT CGC AAA 3'
ParaInfluenza Virus 3		
	PIV 3 FORWARD	TGG YTC AAT CTC AAT CTC AAC AAC AAG ATT TAA G
	PIV 3 REVERSE	TAC CCG AGA AAT ATT ATT TTG CC
	PIV 3 PROBE	5'CC CAT CTG ''T''TG GAC CAG GGA TAT ACT ACA AA 3'

Appendix 6: **Specimen collection form**

Specimen Identification Form

Patient ID number: __ __ __ - __ __ __ __
Date of specimen collection (dd/mm/yyyy): ___ / ___ / _____
Type of specimen (circle one): Both / Oropharyngeal / Nasopharyngeal
Initials of person collecting sample: _____

(Patient Name)

Specimen Identification Form

Patient ID number: __ __ __ - __ __ __ __

Date of specimen collection (dd/mm/yyyy): ___ / ___ / _____

Type of specimen (circle one): Both / Oropharyngeal / Nasopharyngeal

Initials of person collecting sample: _____

(Patient Name)

Specimen Identification Form

Patient ID number: __ __ __ - __ __ __ __

Date of specimen collection (dd/mm/yyyy): ___ / ___ / _____

Type of specimen (circle one): Both / Oropharyngeal / Nasopharyngeal

Initials of person collecting sample: _____

(Patient Name)

Appendix 7: Informed consent for interview about suspected HAI (adults)

The following should be read aloud to study participants by HAI surveillance officer:

Hello, my name is _____. I am a health surveillance officer with The Kenyan Ministry of Health and Centers for Disease Control. Our goal is to make hospitals safer. Right now, we are studying infections that can spread in hospitals. Controlling these infections makes hospitals safer. To understand whether these infections occur here, I have been asking questions of patients with fever. Just because you have a fever does not mean you got an infection from this hospital visit. However, we would like ask you a few questions since your fever started after you came to this ward. If you choose to take part, I will ask you questions about symptoms that started during this hospital visit. Also, I will ask you about any recent hospital visits. The questions will take less than five minutes.

If you agree to take part in our study, I will ask permission to record information from your medical chart. I will record information about symptoms of infection and medications taken for the rest of your visit.

All answers to my questions will be kept private. All information taken from your record will be kept private. No information with your name on it will be shared outside of the hospital. Reports shared with hospital staff will not use your name. Any other information that could possibly identify you will be kept private.

If you take part, we believe that there are no serious risks to you. You will not receive any benefit from participating in this study. However, we believe this information can be used to make future patients safer.

This study is voluntary. You do not have to take part. You can say "no" to participation now or at any time during your hospital visit. If you choose not to participate, your care and treatment will not change.

If you have any questions about your rights as a study member, you may **contact the Secretary or Chairman of KEMRI/NERC: P.O. Box 54840 00200 Nairobi, Telephone: 020 272 2541, 072220590, and 0733400003.** These people are not part of this research project. You may also contact them if you think you have been harmed by this study.

If you have more questions please contact Linus Ndegwa or Mark Katz at the KEMRI/CDC offices in Nairobi (+254-20-271-3008 x176). These people are part of the research study. You may also contact them if you want to quit the study.

By signing below, I consent to a short interview and to take part in this study. I know that I am free not to participate.

Print **Patient** Name: _____ Signature: _____

Print **Guardian** Name[++]: _____ Guardian Signature: _____

Witness*: _____

++ If guardian signs instead of patient, guardian must print and sign their name

**If patient uses thumbprint instead of a signature, consent must be confirmed by the signature of a witness.*

Patient copy of consent for interview about suspected HAI (adults)

You have agreed to take part in a study supported by The Kenyan Ministry of Health and Centers for Disease Control. Our goal is to make hospitals safer. Right now, we are studying infections that can spread in hospitals. Controlling these infections makes hospitals safer. To understand whether these infections occur here, I have been asking questions of patients with fever. Just because you have a fever does not mean you got an infection from this hospital visit. However, we would like ask you a few questions since your fever started after you came to this ward. If you choose to take part, I will ask you questions about symptoms that started during this hospital visit. Also, I will ask you about any recent hospital visits. The questions will take less than five minutes.

If you agree to take part in our study, I will ask permission to record information from your medical chart. I will record information about symptoms of infection and medications taken for the rest of your visit.

All answers to my questions will be kept private. All information taken from your record will be kept private. No information with your name on it will be shared outside of the hospital. Reports shared with hospital staff will not use your name. Any other information that could possibly identify you will be kept private.

If you take part, we believe that there are no serious risks to you. You will not receive any benefit from participating in this study. However, we believe this information can be used to make future patients safer.

This study is voluntary. You do not have to take part. You can say "no" to participation now or at any time during your hospital visit. If you choose not to participate, your care and treatment will not change.

If you have any questions about your rights as a study member, you may **contact the Secretary or Chairman of KEMRI/NERC: P.O. Box 54840 00200 Nairobi, Telephone: 020 272 2541, 072220590, and 0733400003.** These people are not part of this research project. You may also contact them if you think you have been harmed by this study.

If you have more questions please contact Linus Ndegwa or Mark Katz at the KEMRI/CDC offices in Nairobi (+254-20-271-3008 x176). These people are part of the research study. You may also contact them if you want to quit the study.

Appendix 8: Informed consent for interview about suspected HAI (in children <18)

The following should be read aloud to study participants by HAI surveillance officer:

Hello, my name is _____. I am a health surveillance officer with The Kenyan Ministry of Health and Centers for Disease Control. Our goal is to make hospitals safer. Right now, we are studying infections that can spread in hospitals. Controlling these infections makes hospitals safer. To understand whether these infections occur here, I have been asking questions of patients with fever. Just because your child has a fever does not mean they got an infection from this hospital visit. However, we would like ask you a few questions since your child's fever started after he/she came to this ward. If you choose to take part, I will ask you questions about symptoms that started during this hospital visit. Also, I will ask you about any recent hospital visits. The questions will take less than five minutes.

If you agree to take part in our study, I will ask permission to record information from your child's medical chart. I will record information about symptoms of infection and medications taken for the rest of his/her visit.

All answers to my questions will be kept private. All information taken from your child's record will be kept private. No information with your child's name on it will be shared outside of the hospital. Reports shared with hospital staff will not use your child's name. Any other information that could possibly identify your child will be kept private. If you take part, we believe that there are no serious risks to your child. Your child will not receive any benefit from participating in this study. However, we believe this information can be used to make future patients safer.

This study is voluntary. Your child does not have to take part. You can say "no" to your child's participation now or at any time during your hospital visit. If you choose not to participate, your child's care and treatment will not change.

If you have any questions about your rights as a study member, you may **contact the Secretary or Chairman of KEMRI/NERC: P.O. Box 54840 00200 Nairobi, Telephone: 020 272 2541, 072220590, and 0733400003.** These people are not part of this research project. You may also contact them if you think you have been harmed by this study.

If you have more questions please contact Linus Ndegwa or Mark Katz at the KEMRI/CDC offices in Nairobi (+254-20-271-3008 x176). These people are part of the research study. You may also contact them if you want your child to quit the study.

By signing below, I consent to a short interview and to take part in this study. I know that I am free not to participate.

Print **Patient** Name: _____ Signature: _____

Print **Guardian** Name[++]: _____ Guardian Signature: _____

Witness*: _____

++ If guardian signs instead of patient, guardian must print and sign their name

**If patient uses thumbprint instead of a signature, consent must be confirmed by the signature of a witness*

Patient copy of consent for interview about suspected HAI (<18):

You have agreed to take part in a study supported by The Kenyan Ministry of Health and Centers for Disease Control. Our goal is to make hospitals safer. Right now, we are studying infections that can spread in hospitals. Controlling these infections makes hospitals safer. To understand whether these infections occur here, I have been asking questions of patients with fever. Just because your child has a fever does not mean they got an infection from this hospital visit. However, we would like ask you a few questions since your child's fever started after he/she came to this ward. If you choose to take part, I will ask you questions about symptoms that started during this hospital visit. Also, I will ask you about any recent hospital visits. The questions will take less than five minutes.

If you agree to take part in our study, I will ask permission to record information from your child's medical chart. I will record information about symptoms of infection and medications taken for the rest of his/her visit.

All answers to my questions will be kept private. All information taken from your child's record will be kept private. No information with your child's name on it will be shared outside of the hospital. Reports shared with hospital staff will not use your child's name. Any other information that could possibly identify your child will be kept private.

If you take part, we believe that there are no serious risks to your child. Your child will not receive any benefit from participating in this study. However, we believe this information can be used to make future patients safer.

This study is voluntary. Your child does not have to take part. You can say "no" to your child's participation now or at any time during your hospital visit. If you choose not to participate, your child's care and treatment will not change.

If you have any questions about your rights as a study member, you may **contact the Secretary or Chairman of KEMRI/NERC: P.O. Box 54840 00200 Nairobi, Telephone: 020 272 2541, 072220590, and 0733400003.** These people are not part of this research project. You may also contact them if you think you have been harmed by this study.

If you have more questions please contact Linus Ndegwa or Mark Katz at the KEMRI/CDC offices in Nairobi (+254-20-271-3008 x176). These people are part of the research study. You may also contact them if you want your child to quit the study.

Appendix 9: Informed consent for interview about suspected respiratory HAI and swabbing (adults)

The following should be read aloud to study participants by HAI surveillance officer:

Hello, my name is _____. I am a health surveillance officer with The Kenyan Ministry of Health and Centers for Disease Control. Our goal is to make hospitals safer. Right now, we are studying infections that can spread in hospitals. Controlling these infections makes hospitals safer. To understand whether these infections occur here, I have been asking questions of patients with fever and taking throat swabs of patients with fever and respiratory symptoms. We would like ask you a few questions since your fever started after you came to this ward. We would also like to take a throat swab If you allow your child to take part in this study, I will ask you questions about symptoms that you noticed during your child's current visit. Also, I will ask you about any recent hospital visits. The questions and throat swab will take less than 10 minutes.

If you agree to take part in our study, I will ask permission to record information from your medical chart. I will record information about symptoms of infection and medications taken for the rest of your visit.

All answers to my questions will be kept private. All information taken from your record will be kept private. No information with your name on it will be shared outside of the hospital. Reports shared with hospital staff will not use your name. Any other information that could possibly identify you will be kept private.

If you take part, we believe that there are no serious risks to you. You will not receive any benefit from participating in this study. Throat swabs will be tested outside the hospital at a CDC lab in Nairobi. Results will probably not be available in time to affect the care or medicine you receive. However, we believe this information can be used to make future patients safer.

This study is voluntary. You do not have to take part. You can say "no" to participation now or at any time during your hospital visit. If you choose not to participate, your care and treatment will not change.

If you have any questions about your rights as a study member, you may **contact the Secretary or Chairman of KEMRI/NERC: P.O. Box 54840 00200 Nairobi, Telephone: 020 272 2541, 072220590, and 0733400003.** These people are not part of this research project. You may also contact them if you think you have been harmed by this study.

If you have more questions please contact Linus Ndegwa or Mark Katz at the KEMRI/CDC offices in Nairobi (+254-20-271-3008 x176). These people are part of the research study. You may also contact them if you want to quit the study.

By signing below, I consent to a short interview and to take part in this study. I know that I am free not to participate.

Print **Patient** Name: _____ Signature: _____

Print **Guardian** Name^{++}: _____Guardian Signature: _____

Witness*: _____

++ If guardian signs instead of patient, guardian must print and sign their name

*If patient uses thumbprint instead of a signature, consent must be confirmed by the signature of a witness.

Patient copy of consent for interview about suspected respiratory HAI and swabbing (for adults):

You have agreed to take part in a study supported by The Kenyan Ministry of Health and Centers for Disease Control. Our goal is to make hospitals safer. Right now, we are studying infections that can spread in hospitals. Controlling these infections makes hospitals safer. To understand whether these infections occur here, I have been asking questions of patients with fever and taking throat swabs of patients with fever and respiratory symptoms. We would like ask you a few questions since your fever started after you came to this ward. We would also like to take a throat swab. If you allow your child to take part in this study, I will ask you questions about symptoms that you noticed during your child's current visit. Also, I will ask you about any recent hospital visits. The questions and throat swab will take less than 10 minutes.

If you agree to take part in our study, I will ask permission to record information from your medical chart. I will record information about symptoms of infection and medications taken for the rest of your visit.

All answers to my questions will be kept private. All information taken from your record will be kept private. No information with your name on it will be shared outside of the hospital. Reports shared with hospital staff will not use your name. Any other information that could possibly identify you will be kept private.

If you take part, we believe that there are no serious risks to you. You will not receive any benefit from participating in this study. Throat swabs will be tested outside the hospital at a CDC lab in Nairobi. Results will probably not be available in time to affect the care or medicine you receive. However, we believe this information can be used to make future patients safer.

This study is voluntary. You do not have to take part. You can say "no" to participation now or at any time during your hospital visit. If you choose not to participate, your care and treatment will not change.

If you have any questions about your rights as a study member, you may **contact the Secretary or Chairman of KEMRI/NERC: P.O. Box 54840 00200 Nairobi, Telephone: 020 272 2541, 072220590, and 0733400003.** These people are not part of this research project. You may also contact them if you think you have been harmed by this study.

If you have more questions please contact Linus Ndegwa or Mark Katz at the KEMRI/CDC offices in Nairobi (+254-20-271-3008 x176). These people are part of the research study. You may also contact them if you want to quit the study.

Appendix 10: Informed consent for interview about suspected respiratory HAI and swabbing (<18)

The following should be read aloud to study participants by HAI surveillance officer:

Hello, my name is _____. I am a health surveillance officer with The Kenyan Ministry of Health and Centers for Disease Control. Our goal is to make hospitals safer. Right now, we are studying infections that can spread in hospitals. Controlling these infections makes hospitals safer. To understand whether such infections occur here, I have been asking questions of patients with fever and taking throat swabs of patients with fever and respiratory symptoms. We would like ask you a few questions since your child's fever started after you came to this ward. We would also like to take a swab of your child's throat. If you allow your child to take part in this study, I will ask you questions about symptoms that you noticed during your child's current visit. Also, I will ask you about any recent hospital visits. The questions and throat swab will take less than 10 minutes.

If you agree to take part in our study, I will ask permission to record information from your child's medical chart. I will record information about symptoms of infection and medications taken for the rest of your child's visit.

All answers to my questions will be kept private. All information taken from your child's record will be kept private. No information with your child's name on it will be shared outside of the hospital. Reports shared with hospital staff will not use your child's name. Any other information that could possibly identify you will be kept private.

If consent to your child's participation, we believe that there are no serious risks to your child. Your child will not receive any benefit from participating in this study. Throat swabs will be tested outside the hospital at a CDC lab in Nairobi. Results will probably not be available in time to affect the care or medicine your child receives. However, we believe this information can be used to make future patients safer.

This study is voluntary. Your child does not have to take part. You can say "no" to participation now or at any time during your child's hospital visit. If you choose for your child not to participate, your child's care and treatment will not change.

If you have any questions about your rights as a study member, you may **contact the Secretary or Chairman of KEMRI/NERC: P.O. Box 54840 00200 Nairobi, Telephone: 020 272 2541, 072220590, and 0733400003.** These people are not part of this research project. You may also contact them if you think you have been harmed by this study.

If you have more questions please contact Linus Ndegwa or Mark Katz at the KEMRI/CDC offices in Nairobi (+254-20-271-3008 x176). These people are part of the research study. You may also contact them if you want your child to quit the study.

By signing below, I consent to a short interview and to take part in this study. I know that I am free not to participate.

Print **Patient** Name: _____Signature: _____

Print **Guardian** Name^{++}: _____Guardian Signature: _____

Witness*: _____

++ If guardian signs instead of patient, guardian must print and sign their name

**If patient uses thumbprint instead of a signature, consent must be confirmed by the signature of a witness.*

Patient copy of consent for interview about suspected respiratory HAI and swabbing (in children <18):

You have agreed to take part in a study supported by The Kenyan Ministry of Health and Centers for Disease Control. Our goal is to make hospitals safer. Right now, we are studying infections that can spread in hospitals. Controlling these infections makes hospitals safer. To understand whether such infections occur here, I have been asking questions of patients with fever and taking throat swabs of patients with fever and respiratory symptoms. We would like ask you a few questions since your child's fever started after you came to this ward. We would also like to take a swab of your child's throat. If you allow your child to take part in this study, I will ask you questions about symptoms that you noticed during your child's current visit. Also, I will ask you about any recent hospital visits. The questions and throat swab will take less than 10 minutes.

If you agree to take part in our study, I will ask permission to record information from your child's medical chart. I will record information about symptoms of infection and medications taken for the rest of your child's visit.

All answers to my questions will be kept private. All information taken from your child's record will be kept private. No information with your child's name on it will be shared outside of the hospital. Reports shared with hospital staff will not use your child's name. Any other information that could possibly identify you will be kept private.

If consent to your child's participation, we believe that there are no serious risks to your child. Your child will not receive any benefit from participating in this study. Throat swabs will be tested outside the hospital at a CDC lab in Nairobi. Results will probably not be available in time to affect the care or medicine your child receives. However, we believe this information can be used to make future patients safer.

This study is voluntary. Your child does not have to take part. You can say "no" to participation now or at any time during your child's hospital visit. If you choose for your child not to participate, your child's care and treatment will not change.

If you have any questions about your rights as a study member, you may **contact the Secretary or Chairman of KEMRI/NERC: P.O. Box 54840 00200 Nairobi, Telephone: 020 272 2541, 072220590, and 0733400003.** These people are not part of this research project. You may also contact them if you think you have been harmed by this study.

If you have more questions please contact Linus Ndegwa or Mark Katz at the KEMRI/CDC offices in Nairobi (+254-20-271-3008 x176). These people are part of the research study. You may also contact them if you want your child to quit the study.

Appendix 11: Assent form for children aged 7-14 years old for giving specimens for respiratory swab (flesch-kincaid readability score 5.3)

The surveillance officer will read this consent to the child at the time of enrolment.

Introduction

The Kenyan Ministry of Health and Centers for Disease Control and Prevention are carrying out a study to learn more about illnesses that can occur among patients admitted in Kenyan hospitals. We suspect that you may have gotten some germs during your stay in hospital. To learn more about how to prevent healthcare associated infections, we are collecting respiratory samples from patients who experience onset of respiratory illness during their hospital stay.

If you agree to participate, we will need about 5minutes of your time today. We will collect a nose and throat sample by sticking a cotton swab inside your nose and a throat swab. The samples will be taken to CDC IEIP/KEMRI laboratory in Nairobi to test for germs that cause respiratory illness. We will preserve an aliquot of specimen in our laboratory. Results from these tests may not be available in time to affect your Medical care.

Risks to you from participation in this study are minimal. Nose swabs and throat swab cause temporary discomfort. The nose swab might rarely cause brief bleeding from irritation of the nose.

All answers to my questions will be kept private. All information taken from your record will be kept private. No information with your name on it will be shared outside of the hospital. Reports shared with hospital staff will not use your name. Any other information that could possibly identify you will be kept private.

To give samples today is your free choice. If you do not want to, you will still get the best possible medical care here at the hospital. If you do not want to, nobody will be mad at you. If you agree to give samples, but then change your mind, you can stop at any time. We have already asked your parents about this and they said it was okay to ask you if you wanted to do this. If you have any further questions about this study, please ask your parents or me.

Will you be a part of this study and give samples? □ Yes □ No

Name of child (Print) _____

Date_____Child Signature (Signature or mark of consent) _____

To be signed by witness:

The above statement has been read to the child and the child agrees to participate in the research project.

Name of witness (Print) _____

Date_____Witness Signature (Signature or mark of consent)

Appendix 12: Hand hygiene audit form to be used on weekly basis on wards
HAND HYGIENE ADHERENCE DURING <u>HIGH RISK PATIENT CONTACTS</u>

Monitor each clinical area for approximately <u>30 MINUTES</u>

Hospital _____ Date _____ Start time _____ AM / PM (circle)
Section of Hospital (e.g. casualty, adult inpatient, pediatric) _____
Observer name _____ Ward ID ____ Number of patients in ward _____
Total number of sinks or basins in the clinical care area _____
Of these, number that are working at time of audit (i.e. provide water)____
Of these, number used primarily by patients (not including toilet areas)___
Total number of bottles of hand sanitizer in the clinical care area _____

Hand Hygiene Opportunities
Use tick marks to indicate what behaviour was observed for each hand hygiene opportunity

Discipline (see below)	No Attempt	Unsuccessful Attempt	Successful Attempt	Comments

Discipline: M= (Medical Officer, Intern, or Consultant), **N**=Nurse, **CO**=Clinical Officer, **T**= (Technician, Physical Therapist, Respiratory Therapist, Laboratorian), **O=**Other

Duration of observation period: _____ minutes

GUIDE TO HAND HYGIENE OPPORTUNITIES

HIGH RISK FOR TRANSMISSION **Perform hand hygiene before and after each of the following tasks**	
DIRECT PATIENT CONTACT	• Bathing and mouth care • Wound care or dressing changes • Repositioning patient • Direct patient assessment or care • Specimen collection (blood, urine, stool, sputum) • Toileting activities • Physiotherapy activities • Invasive procedures (including, but not limited to, insertion of intravascular devices, administration of IV medication, lumbar puncture, intubation/extubation, bladder catheterization, etc.)
The following Moderate and Low Risk activities should not be monitored during audits	
MODERATE RISK FOR TRANSMISSION Perform hand hygiene between patients	
INDIRECT PATIENT CONTACT	Preparing and administering medications Touching patient equipment at the bedside (eg. Blood pressure cuffs, thermometers) but no patient contact Transporting patient in a wheelchair or stretcher After handling patient soiled linens Before handling food
LOW RISK FOR TRANSMISSION Perform hand hygiene periodically	
ENVIRONMENTAL CONTACT	• Charting or log book entry • Attendance at rounds • Handling stock linens or supplies • After personal toileting

Please make note of the following during this audit session	**Yes**	**No**	**Comments**
Posters promoting hand hygiene are visible			
Waterless hand sanitizer (hand gel) is available for use on the ward			
There is visible and easy access to existing hand hygiene stations			
Soap is available at all hand washing areas			
Paper or clean towels are available for hand-drying at hand washing stations			
Mechanical air driers for hand drying are available at hand washing stations			

ADDITIONAL COMMENTS / OBSERVATIONS

Appendix 13: Research permit

KENYA MEDICAL RESEARCH INSTITUTE

Centre for Vector Biology and Control Research, P.O. Box 1578 - 40100, KISUMU - Kenya,
Tel: (254) (057) 22923/24, E-mail: cvbcr@kisian.mimcom.net Website: www.kemri.org

KEMRI/RES/7/3/1 **23 JULY 2009**

TO: **DR. LINUS NDEGWA (PRINCIPAL INVESTIGATOR)**
GLOBAL DISEASE DETECTION; INFLUENZA ACTIVITY
CDC-KENYA

THROUGH: **DR. J. VULULE,**
THE DIRECTOR, CGHR,
KISUMU

RE: **SSC PROTOCOL No. 1571 (*REVISED*): SURVEILLANCE FOR HOSPITAL ACQUIRED RESPIRATORY ILLNESS IN KENYA**

Dear Sir,

We acknowledge receipt of the translated Informed Consent Documents in Kiswahili and Dholuo and their certificates of back translation.

Due consideration has been given to ethical issues and the study is hereby granted approval for implementation effective this **23rd day of July 2009,** for a period of twelve (12) months.

Please note that authorization to conduct this study will automatically expire on **Thursday, 22nd July 2010.** If you plan to continue with data collection or analysis beyond this date, please submit an application for continuing approval to the ERC Secretariat by **Wednesday, 10th June 2010**.

You are required to submit any amendments to this protocol and other information pertinent to human participation in this study to the ERC prior to initiation. You may embark on the study.

Yours sincerely,

R.C. Kithinji

R. C. KITHINJI,
FOR: SECRETARY,
KEMRI/NATIONAL ETHICS REVIEW COMMITTEE

In Search of Better Health

Appendix 14: Research permit

KENYA MEDICAL RESEARCH INSTITUTE

P. O. Box 54840 - 00200 NAIROBI, Kenya
Tel: (254) (020) 2722541 , 2713349, 0722-205901, 0733-400003; Fax: (254) (020) 2720030
E-mail: kemri-hq@nairobi.mimcom.net: director @ kemri. org; website: www.kemri.org

KEMRI/RES/7/3/1 **30 JULY 2009**

TO: **The Institutional Review Board, National Center for Preparedness, Detection, and Control of Infectious Disease**
Centers for Disease Control and Prevention, Atlanta, GA, USA

RE: **SSC PROTOCOL No. 1571 (*REVISED*): SURVEILLANCE FOR HOSPITAL ACQUIRED RESPIRATORY ILLNESS IN KENYA**

To whom it may concern,

This is to inform you that the KEMRI/National Ethical Review Committee doubles up as the National Ethics Review Committee and as such our approval is countrywide. Two of the three institutions i.e. NNPG and KNH have their own IRB and FWA registration number however we have a Memorandum of Understanding with them such that they do not re-review studies that have been given approval by our ERC. Mbagathi District Hospital relies on KEMRI's Institutional Review Board for review.

Yours faithfully,

R.C. KITHINJI,
FOR: SECRETARY,
KEMRI/NATIONAL ETHICS REVIEW COMMITTEE

cc. Dr. Linus Ndegwa (Principal Investigator)
Global disease detection; Influenza activity
CDC-Kenya.

Appendix 15: The published work

Surveillance for respiratory health care–associated infections among inpatients in 3 Kenyan hospitals, 2010-2012

Contents lists available at ScienceDirect

American Journal of Infection Control

journal homepage: www.ajicjournal.org

Major article

Surveillance for respiratory health care–associated infections among inpatients in 3 Kenyan hospitals, 2010-2012

Linus K. Ndegwa MPHE[a,b,*], Mark A. Katz MD[a], Kelly McCormick MSPH[c], Z. Nganga PhD[c], Ann Mungai MD[d], Gideon Emukule MSc[a], M.K.H.M. Kollmann MD[e], Lilian Mayieka MSc[f], J. Otieno MD[g,b], Robert F. Breiman MD[a], Joshua A. Mott PhD[a], Katherine Ellingson PhD[c]

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Key Words:
Health care–associated infections
Respiratory health care–associated infections
Viral

Background: Although health care associated infections are an important cause of morbidity and mortality worldwide, the epidemiology and etiology of respiratory health care associated infections (rHAIs) have not been documented in Kenya. In 2010, the Ministry of Health, Kenya Medical Research Institute, and Centers for Disease Control and Prevention initiated surveillance for rHAIs at 3 hospitals.
Methods: At each hospital, we surveyed intensive care units (ICUs), pediatric wards, and medical wards to identify patients with rHAIs, defined as any hospital-onset (>3 days after admission) fever (>38°C) or hypothermia (<35°C) with concurrent signs or symptoms of acute respiratory infection. Nasopharyngeal and oropharyngeal specimens were collected from these patients and tested by real-time reverse transcription polymerase chain reaction for influenza and 7 other viruses.
Results: From April 2010-September 2012, of the 379 rHAI cases, 60.7% were men and 57.3% were children <18 years old. The overall incidence of rHAIs was 9.2 per 10,000 patient days, with the highest incidence in the ICUs. Of all specimens analyzed, 45.7% had at least 1 respiratory virus detected; 92.2% of all positive viral specimens were identified in patients <18 years old.
Conclusion: We identified rHAIs in all ward types under surveillance in Kenyan hospitals. Viruses may have a substantial role in these infections, particularly among pediatric populations. Further research is needed to refine case definitions and understand rHAIs in ICUs.

Health care associated infections (HAIs) cause substantial morbidity and mortality worldwide,[1] with prevalence varying from 4%-34% in a variety of patient populations and clinical settings.[2-6]

Although HAI prevalence, incidence, and burden have been characterized by established surveillance systems in several developed countries, data on HAIs in developing countries are sparse, especially in Africa.[7,8] Based on a recent review of published studies of HAI in developing countries, an estimated 15% of hospitalizations resulted in an HAI, which is much higher than estimated rates (4%-10%) in developed countries.[2,5] In developing countries, resource limitations make it more challenging to optimize infection control measures (eg, hand hygiene, proper disinfection of medical equipment and surfaces, injection safety, waste management).[1,9] In addition, some factors that are more common in the developing world (eg, overcrowding of hospital wards, lack of training, fewer

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Disclaimer: The findings and conclusions in this article are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention and Agency for Toxic Substances and Disease Registry.

Financial support: This study was supported by the Centers for Disease Control and Prevention influenza program.

Potential conflicts of interest: All the authors report no conflict of interest relevant to this article.

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programs on prevention of nosocomial infections) can increase the likelihood of transmission of respiratory pathogens in health care settings.[9]

In Kenya, community-acquired acute respiratory illnesses, including pneumonia, are common and may account for up to half of all hospital admissions in medical and pediatric wards.[10,15] However, no data are available on respiratory HAIs (rHAIs) in Kenya. In an effort to understand rHAIs in Kenyan hospitals, in 2009, the Kenya Medical Research Institute (KEMRI), Centers for Disease Control and Prevention-Kenya (CDC-Kenya), and Kenya Ministry of Health established a pilot system for tracking rHAIs in 3 hospitals. Laboratory resources and protocols that have been used for surveillance of community-onset influenza-like illness (ILI) were available for testing a subset of rHAI cases with ILI symptoms. In this study we summarize findings from this pilot surveillance system. Specifically, our objectives were to characterize the epidemiology and etiology of rHAIs stratified by patient and ward characteristics and to identify viral pathogens associated with rHAI in a subset of patients with ILI symptoms.

METHODS

Setting

Three facilities were chosen based on proximity to the KEMRI or CDC-Kenya Laboratories in Nairobi and Kisumu and to ensure sites represented were of varying size and resources. These criteria resulted in the selection of 1 national and 1 district hospital in Nairobi and a provincial (ie, regional referral) hospital in Kisumu. Kenyatta National Hospital (KNH), the largest public hospital in the country, is a university-affiliated national referral hospital with 1,800 beds that receives 89,000 admissions per year. Mbagathi District Hospital (MDH) is a 200-bed hospital with annual admissions of approximately 13,000, which serves the local population but provides no specialty services or intensive care. KNH and MDH are both based in Nairobi, the capital of Kenya, which has a population of about 3 million people. The provincial hospital, New Nyanza Provincial General Hospital (NNPGH), is a 300-bed facility located in western Kenya; it receives approximately 18,000 admissions per year and serves as a regional referral hospital. We targeted medical wards, pediatric wards (which typically admit children <13 years old), and intensive care units (ICUs) for the prospective rHAI surveillance. As a result, there were 394 total patient beds under surveillance: 212 beds in medical wards (51 at KNH, 101 at NNPGH, 60 at MDH), 186 beds in pediatrics wards (61 at KNH, 80 at NNPGH, 45 at MDH), and 26 beds in general ICUs (21 at KNH, 5 at NNPGH).

Surveillance protocol and case definitions

We trained 4 clinicians (1 nurse, 3 clinical officers) to be HAI surveillance officers (SOs) and assigned them to the 3 hospitals (1 in MDH, 1 in NNPGH, 2 in KNH) where they worked closely with the health care personnel and hospital administrators to implement the surveillance protocol. SOs were instructed to survey each ward under surveillance at least 2 days per week. They reviewed all patients' medical records in the selected wards to identify patients with new documented axilla fever (>38°C) or hypothermia (<35°C) with onset at least 3 days after admission to the hospital. SOs relied on temperatures taken as part of routine clinical care and documented in charts. To encourage and enhance consistency of temperature taking, surveillance wards were provided with Omron digital thermometers (Omron, Pudong, China) for axilla temperature taking (thermometer placed in the central position while adducting the arm close to the chest wall). Because temperature taking was found to be inconsistent in the prepilot phase, SOs also took axilla temperatures of all the patients during ward visits to enhance sensitivity of temperature-based surveillance.

Surveillance began on April 1, 2010, and continued through September 30, 2012, which composes the 30-month study period reported here. If new-onset axilla fever or hypothermia were identified in a patient who had been afebrile for at least 3 days, the SOs filled out a suspected HAI form. The form included information on basic demographic characteristics, dates of admission, admitting diagnosis, date of new onset of axilla fever, clinical symptoms occurring from 1 day before to 3 days after the onset of fever or hypothermia, and information about routine laboratory tests ordered, laboratory results obtained, antibiotic use, and details of patient management. SOs also asked patients and patient's family members about clinical symptoms. All patients with a suspected HAI were followed for their ultimate outcome, including patient discharge, transfer, or death.

Based on clinical information collected on suspected HAI cases, respiratory HAIs were characterized by 2 case definitions. The first was a broad definition of rHAIs that incorporated a wide range of respiratory signs and symptoms; the second was a narrower definition for hospital-associated ILI. Specifically, a case of an rHAI was defined as a patient with new-onset fever or hypothermia and concurrent (1 day before to 3 days after) documentation in the medical chart of any of the following indications of respiratory infection: crackles, rhonchi, decreased breath sounds, crepitus, need for supplemental oxygen in nonventilated patients, clinician documentation of upper respiratory infection, clinician request for sputum culture, and oxygen saturation (by pulse oximetry) <90% in ventilated patients or concurrent patient or family report of cough or sore throat. A case of hospital-associated ILI was defined as new-onset fever or hypothermia with concurrent patient or family report of cough or sore throat. Therefore, the hospital-associated ILI cases represented a subset of the rHAI cases (Table 1).

Laboratory testing

Because of laboratory resource constraints, SOs were instructed to collect specimens from patients who met the case definition for hospital-associated ILI only. SOs also collected specimens from a convenience sample of patients who met the rHAI case definition but did not meet the ILI case definition. SOs collected oropharyngeal and nasopharyngeal specimens from eligible patients according to standard procedures that have been previously described.[14] For intubated patients in the ICU in KNH and NNPGH, endotracheal aspirates were collected.

At the KEMRI/CDC-Kenya Laboratory in Nairobi, specimens were tested by real-time reverse transcription (rRT) polymerase chain reaction (PCR) for the following pathogens: influenza viruses A and B; respiratory syncytial virus (RSV); adenovirus; parainfluenza virus types 1, 2, and 3; and human metapneumovirus. We followed the same testing protocol as previously described for population-based acute respiratory illness surveillance in Kenya.[15] For rRT-PCR, total RNA was extracted from 100-μL aliquots of each specimen using QIAamp Viral RNA Mini Kit (Qiagen Inc, Hilden, Germany) according to manufacturer's instructions. One-step rRT-PCR was carried out using the AgPath-ID One-Step RT-PCR Kit (Applied Biosystems, Carlsbad, CA). Pathogen-specific primers were used. Following the reverse transcription step, a typical 45-cycle PCR was run, and fluorescence was read at the annealing and extension step. Appropriate negative and positive control specimens were run alongside each reaction. The results were recorded as crossover threshold (C_T)

Table 1
Demographics and clinical characteristics for cases of suspected HAI, respiratory HAI, and hospital associated ILI, Kenya, 2010–2012

Variable	Suspected HAI* (n = 1,255)	Respiratory HAI† (n = 379)	Hospital associated ILI‡ (n = 147)
Sex			
Male	694 (55.3)	230 (60.7)	85 (57.8)
Female	561 (44.7)	149 (39.3)	62 (42.2)
Age group, years			
<1	206 (16.4)	70 (18.5)	30 (20.4)
1–17	555 (44.2)	147 (38.8)	70 (47.6)
18–49	372 (19.6)	123 (32.5)	40 (27.2)
50–64	80 (6.4)	22 (5.8)	6 (4.1)
>65	42 (3.4)	17 (4.5)	1 (0.7)
Hospital			
KNH	190 (15.1)	103 (27.2)	58 (39.5)
NNPGH	933 (74.3)	220 (58.1)	43 (29.3)
MDH	132 (10.5)	56 (14.8)	46 (31.3)
Ward type			
Pediatrics	690 (55.0)	189 (49.9)	99 (67.4)
Medical	477 (38.0)	116 (30.6)	43 (29.3)
ICU	88 (7.0)	74 (19.5)	5 (3.4)
Length of stay (days) in the ward, median (minimum–maximum)	24 (4–657)	25 (4–288)	29 (6–288)

NOTE. Values are n (%) or as otherwise indicated.
HAI, hospital associated infection; *ICU*, intensive care unit; *ILI*, influenza like illness; *KNH*, Kenyatta National Hospital; *MDH*, Mbagathi District Hospital; *NNPGH*, New Nyanza Provincial General.
*Suspected HAI refers to patients with new documented fever or hypothermia with onset at least 3 days after admission to the hospital.
†Respiratory HAI refers to patients with suspected HAI and with concurrent documentation in the medical chart of indication of respiratory infection.
‡Hospital associated ILI refers to patients with respiratory HAI with concurrent onset of cough or sore throat.

values. Any pathogen C_T value <39.9 was recorded as positive. Specimens with C_T values >40.0 were considered negative, and those without a C_T reading were recorded as negative.

Data analysis

Incidence was calculated by dividing the number of rHAIs and hospital-associated ILI cases identified by the number of patient days under surveillance; the patient-day denominator was determined from monthly ward-specific bed occupancy data provided by each hospital. We used all patient days rather than patient days at risk (ie, eliminating patient days for those discharged from the hospital after a stay <3 days) because using overall patient days has become standard protocol where most patient days are contributed by patients with lengths of stay >3 days.[16] Incidence rates for rHAIs and ILIs were calculated overall and by hospital and ward type. Stratified incidence rates were compared using a Poisson regression (Table 2). Median length of stay was calculated by ward type and differences compared using Wilcoxon rank-sum tests. Longitudinal trends were plotted quarterly by hospital. Viral pathogen test results were summarized for patients with hospital-associated ILI and rHAI.

We analyzed outcomes related to patient discharge status for those with rHAI. Because patients could have >1 HAI during the study time period, outcomes were analyzed at the patient level. Death within 7 days of rHAI onset was used as a proxy for death attributable to an HAI.[17] For patients with multiple rHAIs, the time from rHAI onset to death was based on the onset of their last rHAI. Characteristics of patients who died within 7 days of onset of rHAI were compared with patients who died after 7 days and patients who did not die using χ^2 tests for independence.

SOs collected all data on paper-based forms until November 30, 2011, at which point they switched to electronic collection of data on tablets. Data were manually entered into Microsoft Access 2007 (Microsoft Inc, Redmond, WA) prior to December 2011, after which data were downloaded directly into Microsoft Access from tablets. Statistical analysis was performed using SAS software version 9.1 (SAS Institute, Cary, NC). The surveillance protocol was approved by both the Institutional Review Board of CDC-Atlanta and the Ethical Review Committee of KEMRI.

RESULTS

The surveillance period (April 2010–September 2012) included a total of 410,182 patient days at the 3 hospitals: 162,394 on medical wards, 225,354 on pediatric wards, and 22,434 in ICUs. During this time, SOs identified 1,255 cases of suspected HAIs; 379 (30.2%, including 18 patients with >1 case) met the definition for rHAI, and 147 (11.7%, including 1 patient with 2 cases) cases met the definition for hospital-associated ILI. Of the 379 rHAI cases identified, 60.7% were men, and 57.3% were <18 years of age. Of the 147 ILI cases identified, 57.8% were men, and 68.0% were <18 years of age; 20.4% were <1 year of age (Table 1). Of the 379 rHAI cases identified, 49.9% were in pediatrics wards, 30.6% were in medical wards, and 19.5% were in the ICUs. The median length of stay in the hospital for rHAI patients was 25 days (range, 4–288); there was no statistically significant variation by ward type.

The overall incidence of rHAI was 9.2 infections per 10,000 patient days under surveillance (Table 2). The incidence of rHAIs in the ICUs was 33.0 per 10,000 patient days, which was significantly higher than the incidence in pediatric wards (8.4 per 10,000 patient days, $P < .0001$) and medical wards (7.1 per 10,000 patient days, $P < .0001$). There was no statistically significant difference in the incidence of rHAI in the pediatrics wards compared with the medical wards. The incidence of rHAI differed significantly by hospital; it was 18.1 per 10,000 patient days at the NNPGH, 8.4 at the KNH, and 3.4 at the MDH ($P < .0001$ for all comparisons).

The overall incidence of hospital-associated ILI was 3.6 per 10,000 patient days (Table 2). By ward type, the incidence was higher in the pediatrics wards at 4.4 per 10,000 patient days than the medical wards (2.6, $P < .0001$) and ICUs (2.2, $P = .13$). By hospitals, the incidence of hospital-associated ILI was highest at the KNH at 4.7 per 10,000 patient days. KNH incidence was higher than the MDH (2.8, $P = .007$) and NNPGH (3.5, $P = .15$); however, the latter comparison did not reach statistical significance.

HAIs were detected throughout the year without any clear seasonal trends. A notable drop in case identification occurred in the last quarter of 2011, and a notable increase in rHAI rates occurred between March and November 2011 at the NNPGH (Fig 1).

Specimens were collected and tested for 112 of the 147 suspected hospital-associated ILI cases (76.2%). When we compared patients from whom specimens were collected with patients from whom specimens were not collected, there were no significant differences in age, sex, ward type, or hospital. Reasons for not collecting specimens included refusal by patient or their guardian or inability to obtain a specimen (eg, because of oxygen mask use, severe difficulty breathing). Among hospital-associated ILI cases, 54 (48% of specimens tested) were positive for at least 1 viral pathogen (Table 3). The most common viruses identified among specimens tested were adenovirus (n = 19, 18.5%), RSV (n = 17, 16.5%), parainfluenza virus type 3 (n = 16, 15.3%), and influenza virus A (n = 9, 8.7%). Multiple viruses were isolated for 17 (16.5%) ILI specimens. Among the 54 ILI cases with any virus identified, 53 (98.2%) were <18 years old, and 20 (37.0%) were <1 year old.

Table 2
Incidence of respiratory HAI and hospital associated ILI per 10,000 patient days by ward type and hospital, Kenya, 2010–2012

	KNH		NNPGH		MDH		Overall	
Ward type	Respiratory HAI	Hospital associated ILI	Respiratory HAI	Hospital associated ILI	Respiratory HAI	Hospital associated ILI	Respiratory HAI	Hospital associated ILI
Medical	4.4	4.2	11.5	1.4	4.0	3.2	7.1	2.6
Pediatrics	6.5	5.6	21.5	6.5	3.0	2.6	8.4	4.4
ICU	21.9	2.5	111.6	0.0	NA*	NA	33.0	2.2
Overall	8.4	4.7	13.3	2.6	4.6	3.8	9.2	3.6

HAI, hospital associated infection; *ICU*, intensive care unit; *ILI*, influenza like illness; *KNH*, Kenyatta National Hospital; *MDH*, Mbagathi District Hospital; *NA*, not applicable; *NNPGH*, New Nyanza Provincial General.
*MDH has no ICU

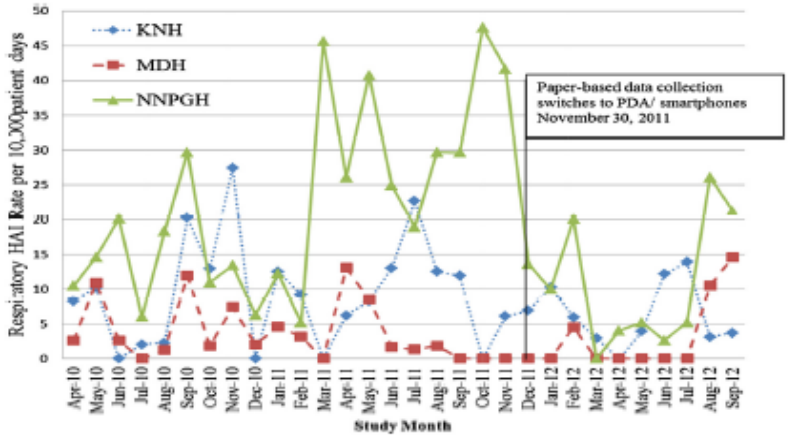

Fig 1. Overall respiratory HAI incidence reported per 10,000 patient days by hospital, Kenya, 2010–2012. *HAI*, health care–associated infection; *KNH*, Kenyatta National Hospital; *MDH*, Mbagathi District Hospital; *NNPGH*, New Nyanza Provincial General; *PDA*, personal digital assistant

Table 3
Viral pathogens detected among patients with respiratory HAI, Kenya, 2010–2012

Variable	Total respiratory HAI (n = 379)	Respiratory HAI with hospital associated ILI* (n = 147) n (%)
Samples collected for viral testing†	153 (40.4)	112 (76.2)
Sample results available†	140 (36.9)	103 (70.0)
Any virus*	64 (45.7)	54 (52.4)
Influenza virus A*	13 (9.3)	9 (8.7)
Influenza virus B*	10 (7.1)	8 (7.7)
Adenovirus*	22 (15.7)	19 (18.5)
Respiratory syncytial virus*	17 (12.1)	17 (16.5)
Human metapneumovirus*	6 (4.3)	4 (3.9)
Parainfluenza virus type 1*	4 (2.9)	3 (2.9)
Parainfluenza virus type 2*	2 (1.4)	2 (1.9)
Parainfluenza virus type 3*	18 (12.9)	16 (15.5)
Multiple viruses detected	20 (14.2)	17 (16.5)

NOTE Values are n (%).
HAI, hospital associated infection; *ILI*, influenza like illness.
*Denominator for the percentage reported is the number of cases that were swabbed with results available.
†Denominator for the percentage reported is the number of cases meeting the case definition.

From the 232 rHAI cases that did not meet the definition for hospital-associated ILI, we collected a convenience sample of 37 specimens of which 10 (27%) were positive for at least 1 viral pathogen. Of these, 6 specimens were identified from the 69 non-ILI rHAI cases in the ICUs. The remaining 4 specimens were identified from the 90 non-ILI rHAI cases in the pediatric wards. Overall, 92.2% of all positive specimens were from patients <18 years old.

Of the 351 patients with at least 1 case of rHAI, 207 (59.0%) were discharged from the hospital, 78 (22.2%) died, 36 (10.3%) transferred, 16 (4.6%) absconded, and 14 (4.0%) were still in the hospital at the final date of data collection. Of the 78 patients who died, 41 (52.6%) of the deaths occurred within 7 days of a new rHAI case (Table 4). Overall, 10 (58.8%) of the rHAI patients >65 years old died in the hospital; of those, 6 died within 7 days of having an rHAI. The proportion of death within 7 days among patients with at least 1 case of rHAI was highest in the ICUs and lowest in pediatric settings (16.4% vs 9.6%, $P = .0001$). Fewer patients who had an identified virus died within 7 days (4.9%) compared with patients who did not have any virus identified (9.9%, $P = .007$). Among rHAI patients, having a hospital-associated ILI was not significantly associated with death (Table 4).

DISCUSSION

In this study we report the first, to our knowledge, systematically collected surveillance data in East Africa to estimate the incidence and viral etiology of rHAI illness. At 3 hospitals in Kenya, over half of the rHAIs and two thirds of the hospital-associated ILI cases were identified in pediatric wards. Incidence of rHAI was highest in ICUs, whereas incidence of hospital-associated ILI was highest in pediatric wards. Nearly all of the virus-positive hospital-associated ILI cases occurred in patients <18 years of age, suggesting that virus transmission among infant and child patients is an important infection control priority. Although virus positivity among rHAI patients in ICUs was lower, the high overall incidence of rHAI in ICUs suggests that both the specificity of the rHAI case

Table 4
Characteristics of patients that died within 7 days of respiratory health care–associated infection and patients who died after 7 days among 337 patients with at least 1 respiratory health care–associated infection case with outcome information available (ie, not in hospital at time of final data collection)

Variable	Total (n = 337)	Died <7 days (n = 41, 12.2%)	Died >7 days (n = 37, 11.0%)	Died all (n = 78, 23.1%)
Sex				
Male	203	23 (11.3)	19 (9.4)	42 (20.7)
Female	134	18 (13.4)	18 (13.4)	36 (26.9)
Age, years				
<1	59	7 (11.9)	4 (6.8)	11 (18.6)
1–17	128	11 (8.6)	9 (7.0)	20 (15.6)
18–49	113	14 (12.4)	17 (15.0)	31 (27.4)
50–64	20	3 (15.0)	3 (15.0)	6 (30.0)
>65	17	6 (35.3)	4 (23.5)	10 (58.8)
Ward type				
ICU	61	10 (16.4)	14 (23.0)	24 (39.3)
Medical	109	15 (13.8)	15 (13.8)	30 (27.5)
Pediatrics	167	16 (9.6)	8 (4.8)	24 (14.4)
Any influenza–like illness				
Yes	139	13 (9.4)	15 (10.9)	28 (20.3)
No	186	26 (14.0)	21 (11.3)	47 (25.3)
Any virus identified*†				
Yes	61	3 (4.9)	6 (9.8)	9 (14.8)
No	71	7 (9.9)	18 (25.4)	25 (35.2)
Length of stay, days				
Median (minimum–maximum)		11 (5–67)	38 (12–244)	NA

NOTE. Values are n (%) or as otherwise indicated.
NA, not applicable.
*Total here is the number of patients who were sampled with results available.
†Viruses were much more commonly detected in the pediatric population.

definition and the possibility of bacterial rHAI be further evaluated in ICU patients.

At the 3 surveillance hospitals in Kenya, the overall rHAI rate was 9.2 per 10,000 patient days. Although there are few comparable studies documenting incidence rates of rHAIs in these settings, our estimates of an incidence of 8.4 infections per 10,000 patient days in pediatric wards in Kenya are consistent with a study from Canada that reported an incidence of 2.9–15.0 rHAIs per 10,000 patient days[18] in the pediatric population. Our findings are also similar to rHAI incidence rates of 7.9 per 10,000 patient days reported in Germany in 2004 for children <3 years old.[19] One primary risk factor for rHAI was the use of respirators, which were present in the hospitals where both the Canadian and German studies were conducted; respirators were uncommon in our 3 study sites. Although this difference complicates the comparison of our findings with these 2 studies, our findings still provide baseline estimates that have some consistency with rHAI rates observed elsewhere.

There are also some notable differences between our findings and other published studies on rHAIs. A study conducted in Bangladesh in 2011 found the incidence of rHAI to be 5-fold higher than what we have documented in Kenya.[3] This difference could be caused by differences in data collection strategies; in Bangladesh, staff gathered data on all rHAIs by visiting wards daily, whereas in Kenya we gathered data on all rHAIs by visiting the wards twice per week. It is also possible that rates of HAI are significantly higher in Bangladesh than in Kenya because of hospital crowding or possibly because of differences in infection control practices. During the surveillance period we introduced health education sessions to health care providers at the 3 study hospitals to improve infection control practices (eg, hand hygiene). Although the impact of these health education sessions has not been evaluated formally, it is possible that the education sessions led to improvements in infection control in the 3 hospitals, which could also explain why our reported rHAI rates are lower than those reported in Bangladesh.

The percentage of virus-positive samples and the main viruses we identified were similar to findings from recent reports of general acute respiratory illness surveillance in Kenya; a recent study of acute respiratory illness in older children and adults in rural western Kenya showed similar percent-positive results for inpatients in regard to any virus identified (58% compared with 46% presented here), influenza virus A (10% compared with 9% presented here), and RSV (12% compared with 12% presented here).[20] Another study reported similar rates of viral pathogens among infants and children at a rural Kenyan hospital (56% positive for at least 1 virus), a slightly lower percentage of specimens positive for influenza virus A (5.8%), and a higher percentage of RSV–positive samples (5.8%).[21]

In the 30 months of HAI surveillance presented in this study, nearly a quarter of patients with rHAI died while they were in the hospital, and over half of those deaths were within 7 days of being diagnosed with an rHAI. Although this study did not measure death attributable to rHAI, death within 7 days of diagnosis may serve as a proxy indicator.[17] The proportion of rHAI cases with an outcome of death is higher than reported in similar studies. In a Canadian study, 9% of febrile rHAI cases died; in a study from Bangladesh, 2% of rHAI patients died.[3,6] These differences suggest the possibility that our surveillance may have not detected milder cases of HAI; if so, this may also help to explain the differences in rates of rHAI.

Our data have several limitations that reflect the challenges of sustaining surveillance in low resource settings. Data reported here may be an underestimation of rHAI for 2 reasons. First, SOs only visited wards at the most 2 days per week; therefore, they relied on chart documentation to measure patient temperatures when they were not at the ward. Wards were understaffed, and thermometers were scarce; as a result, temperatures were measured and recorded inconsistently in hospital charts. Therefore, rHAI cases were likely missed. To address some of these issues, we supplied the surveillance wards with digital thermometers and encouraged the ward nurses to record temperatures. In addition, we likely missed a number of etiologies of rHAIs because we only tested for some viruses and did not test for bacteria. Further, we did not follow-up on any patients following discharge from the wards who may have developed symptoms from new infections after discharge from the hospital. Finally, although we chose 3 different kinds of hospitals

(national, provincial, district), our results may not be representative of all hospitals in Kenya.

To draw on these limitations, lessons learned from the establishment of this surveillance suggest that future routine HAI surveillance will require more consistent temperature monitoring by the ward staff and improved documentation of fever on patient charts. Also, none of the 3 hospitals had any dedicated infection control nurses. Dedicated infection control staff who have continual support from the hospital administration and ward staff can promote HAI awareness and support HAI surveillance efforts.

In conclusion, a new surveillance system for rHAI in 3 hospitals in Kenya showed that rHAI occurred consistently during a 30-month period in the pediatric and medical wards and ICUs of 3 hospitals in rates similar to those described in other developing countries. Most ILI cases tested were positive for at least 1 viral pathogen. Infection control measures should be strengthened in Kenyan hospitals, and continued HAI surveillance will be important to monitor the burden of HAIs and the impact of future infection control interventions.

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Molecular characterization of potential healthcare associated respiratory syncytial virus in three referral hospitals in Kenya, 2009-2011

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ANTIMICROBIAL RESISTANCE & INFECTION CONTROL

POSTER PRESENTATION Open Access

Molecular characterization of potential healthcare associated respiratory syncytial virus in three referral hospitals in Kenya, 2009-2011

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From 3rd International Conference on Prevention and Infection Control (ICPIC 2015)
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Introduction

Respiratory syncytial virus (RSV) is a major cause of community-acquired severe respiratory illness in infants, immunocompromised individuals and the elderly. Limited information exists on healthcare associated RSV infections in developing countries.

Objectives

To describe hospital-acquired RSV infections in three Kenyan referral hospitals

Methods

Ongoing surveillance for healthcare associated infections is conducted at three referral hospitals in Nairobi: Kenyatta National Hospital (KNH), Jaramogi Oginga Odinga Teaching and Referral Hospital (JOOTRH) and Mbagathi District Hospital (MDH). We collected nasopharyngeal and oropharyngeal samples from patients with new-onset fever (≥38°C) and either cough or sore throat, after being afebrile for at least three days in the wards. Specimen were tested for RSV using real time polymerase chain reaction (RT-PCR) and those positive with a cycle threshold value of 30 and below were further grouped as RSV A or B using the same method. The ectodomain of the attachment G glycoprotein was sequenced and phylogenetically analyzed.

Results

Among 255 cases tested from September, 2009 to September, 2011, 37 (14.5%) were positive for RSV, including 13 (35%) subgroup A, 6 (16%) B, 1 (3%) mixed AB and 17 (46%) could not be determined. Seventeen samples were successfully sequenced out of the twenty samples on which this was attempted. Majority of our RSV A isolates belonged to NA1 genotype prototype strain and all RSV B sequences clustered with the BAIV genotype. Three RSV A and 2 RSV B sequences from patients on the same ward at KNH were 100% identical in the G ectodomain suggesting potential common source. One RSV A positive specimen from MDH and one from JOOTRH showed 100% sequence identity.

Conclusion

Presence of identical sequences indicates potential patient to patient transmission of RSV within the hospitals. Effective and feasible infection control strategies should be enhanced in the Kenyan public hospitals.

Disclosure of interest

None declared.

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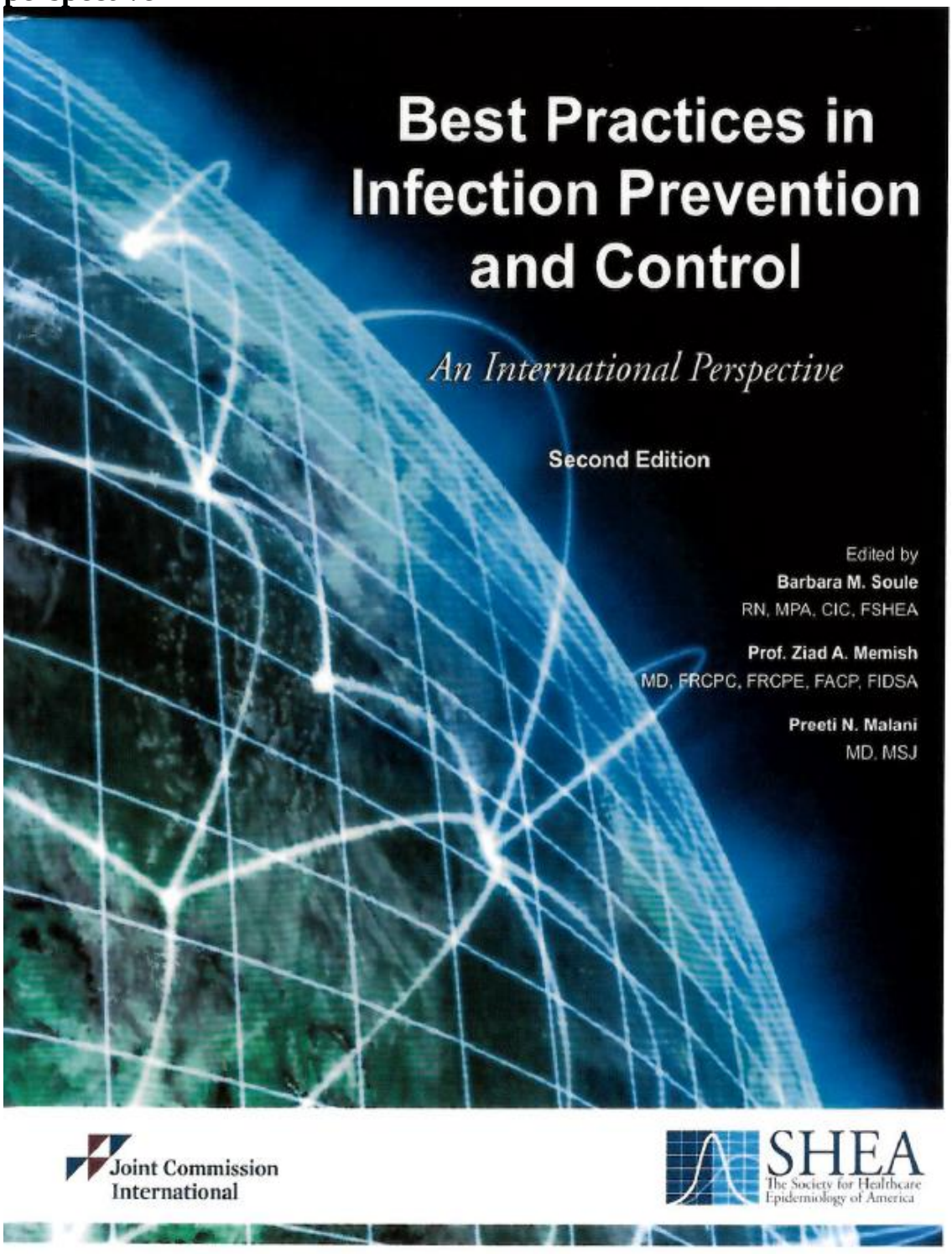
Best practices in infection prevention and control: an international perspective



Sidebar 7-1. Developing a National Infection Prevention and Control Policy: The Ministry of Health, Kenya

Ndegwa Linus, MPHE, HCS, PhD (SHEA International Ambassador)

Gathari Ndirangu, MBChB, MMed

Rachel Kamau, BDS, NASCOP

Susan Otieno, MPHE

Introduction

Health care in Kenya includes public and private sectors. In 2008, the government's Ministry of Health (MOH) was split into two ministries—the Ministry of Medical Services and Ministry of Public Health and Sanitation. The private sector consists of private for-profit, faith-based, and nongovernmental organization facilities. Health services are provided through a network of more than 6,000 health facilities nationwide, with the public-sector system accounting for about 51% of these facilities.

The Kenyan government, through the MOH, recognized that HAIs were a problem within the health care system and had put in place various policies addressing aspects of IPC in the country. However, the country lacked a comprehensive IPC policy to guide HCWs on the issues of infection control practices.

The Process

In 1998 some MOH staff were sensitized on IPC concept through various workshops organized by WHO. These staff started the process of developing IPC policy but faced many challenges, including transfers, retirements, and the lack of a well-coordinated team to spearhead the process. This led to collapse of the process until 2004, when a US President's Emergency Plan for AIDS Relief (PEPFAR)–funded project (making medical injection safe, or MMIS) was implemented by an outside consultant. MMIS worked with the MOH to establish an injection-safety task force, which revived interest in the IPC with a bias on injection-safety practice in the country. The task force developed a policy and standard guidelines on injection safety.

In August 2009 the MOH began the process of developing the National IPC Policy and Guidelines for Health Care Services in Kenya. This process began with a situational analysis to determine IPC practices and to identify the gaps for such practices. The analysis was made through interviews and direct observation of practice with policy makers and health care workers in public, private, and faith-based health sectors across various regions of the country. The analysis identified a need for simple, user-friendly IPC policies and guidelines for all types of staff at all levels of the health care system. The situational analysis revealed that few facilities had active IPC committees, while others were inactive, having not met for more than six months prior to the situational analysis. The need to set up active IPC committees in all health care facilities was identified as critical to strengthen IPC. A subsequent stakeholder forum agreed on the need for a national policy on IPC as well as guidelines for all health care services in the country to help the facilities practice IPC uniformly.

Results

In September 2009 a national committee to spearhead development of the IPC Policy and Guidelines was formed, with members drawn from the national MOH office and health care providers from public, private, and faith-based health sectors, medical training institutions, and nongovernmental organizations. This committee conducted a technical appraisal of a draft of National IPC Policy and Guidelines that had been prepared by a consultant contracted to lead the process. The draft was later reviewed by national and international IPC experts during a regional IPC workshop in November 2009.

The committee met regularly to review the inputs from various experts. The National IPC Policy was also reviewed by the MOH departmental heads, who gave their input and took ownership of the policy and guidelines development. The National IPC Policy and Guidelines for Health Care Services in Kenya were subsequently edited and finalized. The final document was later printed, launched, and disseminated to HCWs in the country.

The National IPC Policy for Health Care Services in Kenya aims to promote high standards of IPC to reduce the risk of HAIs and to improve the safety of patients, clients, HCWs, and the general public in Kenya. It identifies the roles and responsibilities of the various players in promoting IPC practice, the legal and regulatory framework for best IPC practice, continuous quality improvement, promotion of HCW safety, and advocacy and resource mobilization for IPC. The National IPC Guidelines for Health Care Services in Kenya aim to standardize IPC practice in the country by using evidence-based best practices. The guidelines provide the procedures for carrying out standard and transmission-based precautions, including isolation, environmental management practices, traffic flow, instrument and equipment processing, laboratory safety and precautions, laundry and linen processing, HCW occupational safety, and prevention of HAIs.

These documents were developed through the collaborative efforts of the MOH, the US CDC, other implementing partners, and other key stakeholders demonstrating genuine public-private partnership in the improvement of health care in Kenya toward achievement of the United Nations' Millennium Development Goals (MDGs) and national health goals. Through these efforts, HCWs now have documents that allow them to practice IPC in a standard way; to define the procedures, roles, and responsibilities for IPC committees; and to provide a platform for continuous quality improvement.

Lessons Learned

Developing a national infection control policy requires MOH commitment, collaboration, and partnership with key stakeholders. Qualitative data from the situational analysis were used to inform the process of developing the documents.

https://books.google.co.ke/books?hl=en&lr=&id=6aiuSXQGCnAC&oi=fnd&pg=PR1&dq=assesment+of+hand+hygiene+by+linus+ndegwa&ots=38PZchDICJ&sig=wRWpd0ObwSv0mHwzDRu2kI5LN0s&redir_esc=y#v=onepage&q&f=false

Assessment of Hand Hygiene Practices And Usage of Alcohol-Based hand Sanitizer in Three Kenyan Hospitals, 2011-12

1509. Assessment of Hand Hygiene Practices And Usage of Alcohol-Based hand Sanitizer in Three Kenyan Hospitals, 2011-12

Linus Ndegwa, MPHE; Infection Control, KEMRI, Nairobi, Kuwait

Session: 195. Hand Hygiene
Saturday, October 11, 2014: 12:30 PM

Background. Hand hygiene (HH) by healthcare providers (HP) prevents healthcare-associated infections. Routine use of alcohol-based handrub (ABHR) increases HH adherence but can be cost-prohibitive. The World Health Organization (WHO) published methods for local production of ABHR to sustain supply and control costs in low-resource settings. The objective was to describe: 1) baseline HH adherence; 2) perceptions of locally-produced ABHR among HP; and 3) cost savings associated with local production of ABHR in 3 Kenyan hospitals.

Methods. Baseline HH adherence was defined as the number of successful HH events (HH with soap and water or ABHR) divided by the number of WHO-defined HH opportunities observed. Baseline HH adherence data was collected from December 2011 to May 2012 by trained observers in 16 wards. Differences in adherence by ward, HP type and before and after ABHR introduction were assessed using χ^2 tests. Nine focus groups were conducted with doctors, nurses, and other providers to assess perceptions of ABHR; transcripts were qualitatively coded using a standardized approach to describe key themes. ABHR was prepared in the hospitals using the published WHO formulation; data were collected from April 2012 to April 2013 and compared to the average wholesale cost of 8 brands of ABHR available to hospitals.

Results. Baseline HH adherence was 28%. ICU had the highest rates, while surgical and pediatric wards the lowest (figure). HH adherence significantly varied by HP type; doctors and clinical officers had the lowest adherence. Focus group respondents most often reported liking ABHR because it is fast and efficient to use and its perceived efficacy; dislikes included its smell and the residue it left on hands. Product availability was the dominant theme for sustainability, particularly "constant supply," "strategic placement" and "cheaper production." Production cost of ABHR was US$3.10 per liter compared to an average commercial purchase price of US$24.50. Throughout the pilot, 2166 litres of ABHR were used in the sites, with average monthly savings of $8503.

Figure 1: Baseline HH adherence 1st Dec 2011 to 31st May 2012

	Total # of Hand Hygiene Opportunities Observed	Overall Hand Hygiene Adherence (HH events/ opportunities)	Chi-square test of homogeneity (p-value)
Overall	5027	28%	
Ward			<0.0001
ICU	786	45%	
Medical	944	31%	
Specialty	1351	29%	
Pediatrics	1207	22%	
Surgical	709	15%	
Healthcare Personnel Type			<0.0001
Medical Officers	913	22%	
Clinical Officers	834	22%	
Nurses	1432	31%	
Students	708	31%	
Technicians*	153	32%	
Others*	987	32%	

*Technicians: Laboratory technician, Physical Therapist, Occupational Therapist
*Others include Nutritionists, patient attendants.

Conclusion. There is low HH adherence in Kenyan hospitals. Local production may provide a cost-saving sustainable source of ABHR that could improve HH adherence by Kenyan HP who like ABHR for its time-efficiency and perceived efficacy.

Disclosures. **All authors:** No reported disclosures.

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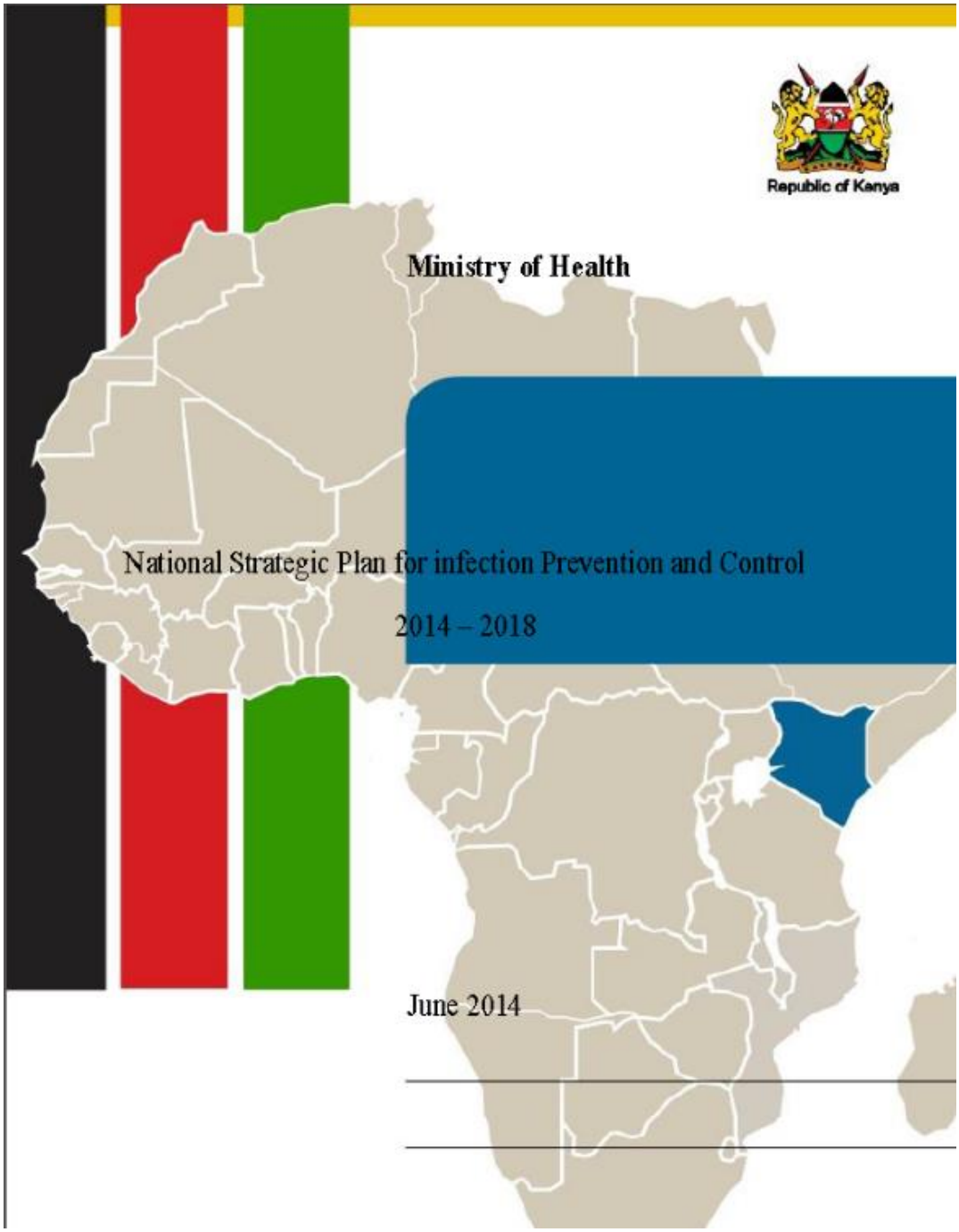
National Strategic Plan for infection Prevention and Control, 2014-18



Ministry of Health

National Strategic Plan for Infection Prevention and Control

2014-2018

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