COLLEGE OF MEDICINE AND HEALTH SCIENCES

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MASTERS OF HOSPITAL AND HEALTHCARE ADMINISTRATION (MHA).

REDUCING VENTILATOR- ASSOCIATED PNEUMONIA IN INTENSIVE CARE UNIT AT KING FAISAL HOSPITAL, KIGALI.2020-2022

A study report submitted to the college of Medicine and Health Sciences, School of Health Sciences of the University of Rwanda in partial fulfillment of the requirement for the Degree of MASTERS IN HOSPITAL AND HEALTHCARE ADMINISTRATION.

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Kigali April, 2022

DECLARATION

I, **Jean Baptiste De La Salle NGIRIMANA**, declare that this study report is my own work. It is being submitted for the Degree of Master of Health Sciences at University of Rwanda. It has not been submitted before for any degree or examination at this or any other university.

Signature_____ Date ..…./…../2022

Jean Baptiste De La Salle NGIRIMANA,

Supervisor's Declaration

I confirm that to the best of my knowledge:

- ✓ The study was carried out and the dissertation was prepared under my direct supervision;
- ✓ The study was conducted in accordance with the degree regulation;
- ✓ The capstone dissertation represents the original work of the candidate;
- ✓ The contribution made to the study by me, by other members of the supervisory team, by other member of staff of the University of Rwanda and by others was consistent with normal supervisory practice;
- ✓ External contributions to the research are acknowledged.

Signed at University of Rwanda

Supervisor _____ Date ....…. /...…../2022

DEDICATION

I dedicate this work to the Almighty God, who gave me life and the chance to elaborate this work.

I also dedicate this work to my friends for the love and support that strengthened and encouraged me throughout this study process. This work is furthermore dedicated to my wife, brothers and sister whose words of encouragement and push for tenacity ring in my ears.

A special feeling of gratitude to my loving parents who taught me that even the largest task can be accomplished if it is done one step at a time. All you have been my best cheerleaders.

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ABSTRACT

The most frequent complication for patients in intensive care units (ICUs) is ventilator-associated pneumonia (VAP), which has a significant morbidity. VAP is a lung infection that develops during or after intubation and mechanical ventilation. It is characterized by signs of infection (fever, altered white blood cells counts..), purulent tracheal discharge, along with radiological evidence of pneumonia (new or progressive infiltrate). VAP occurs within 48-72 hours and imposes a significant burden by contributing to more than the half of all hospital-acquired pneumonia. After identification of high VAP rate 36% in ICU KFH following Infection Prevention and Control report with confirmation of baseline data.

The main objective of this pre and post interventional study is the reduction of VAP rate from 36 to 13%.

With two process indicators increase knowledge of ICU clinical staff by trainings and increasing compliance rate of Evidence Based Guideline (EBG) of VAP preventive measures.

This pre and post intervention study analyzed data of two different periods: The first period was considered as pre intervention period (October, November and December 2019) and Post intervention period (October, November and December 2021). Among 150 patients admitted only 74 patients were chosen in study and they were intubated more than 48 hours. After finding the real root cause; **Low compliance level of Evidence Based Guideline on VAP prevention**" 55.8% due to lack of clinical staff training on VAP preventive measures. Several training conducted from August to September 2021 and some techniques demonstration of VAP preventions measures.

This pre post interventions study was very successful and the main objective was achieved. The results shows VAP rate of 36 % in 2019 before all ICU staff training on EBG for VAP preventive measure compare to, 10% in 2021 which confirm the success of the intervention. This study had also 3 major outcomes; increasing staff knowledge on VAP preventive measures by staff training, from 12.5% to 96%, increase compliance rate of EBG's from 55.8% to 86.2% and finally VAP rate reduction from 36% 10%. This means all outcomes were achieved.

Conclusion: clinical staff training lead to increase compliance rate of EBG's and finally to VAP rate reduction. There is strong relationship (CI: 95%) between training and VAP incidence rate.

Key Words: Ventilator -Associated Pneumonia, Evidence Based Guidelines and clinical staff training on VAP preventive measures.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACCCN : Australian College of Critical Care Nurses

CAI : Community Acquired Infection

CAUTI : Catheter associated urinary tract infection

CDC **:** Center for Diseases Control

CHUB/UTHB : Centre Hospitalier Universitaire de Butare/ University Teaching Hospital of Butare

CHUK/UTHK: Centre Hospitalier Universitaire de Kigali/University Teaching Hospital of Kigali

CPIS **:** Clinical Pulmonary Infection Score

CSSD **:** Central Sterile Supplies Department

DR : Doctor

EBGs : Evidence Based Guidelines

ETT : Endo Tracheal Tube

GP : General Practionner (Doctor)

HAI : Hospital Acquired infection

HAP : Hospital Acquired Pneumonia

HCAI : Healthcare associated infections

HME : Heat and Moisture Exchangers

HVAC : Heating, ventilation and air conditioning

ICU : Intensive Care Unit

IPC : Infection, prevention and control

KFH,K : King Faisal Hospital Kigali

MDR : Multi-drug resistant

MHA : Masters of Hospital & Healthcare Administration

MOH **:** Ministry of health

MRB : Medical Referral Board

MRSA : Methicillin Resistant Streptococcus Aureus

NC : Non-compliant

NRH/UTH : National Referral and University Teaching Hospitals

PC : Partial compliant,

PG : Post Graduate (Doctor)

POCCS **:** Peri-Operative and Critical Care Services

PPE **:** Personal Protective Equipment

RCA : Root Cause Analysis

RN : Registered Nurse

SPSS : Statistical Package for Social Sciences

VAE **:** Ventilator Associated Events

VAI : Ventilator Associated Infections

VAP **:** Ventilator -Associated Pneumonia

WHO : World Health Organization

DEFINITION OF KEY TERMS

VAP: Ventilator-associated pneumonia (VAP) is defined as pneumonia that occurs 48–72 hours or thereafter following endotracheal intubation, characterized by the presence of a new or progressive infiltrate, signs of systemic infection (fever, altered white blood cell count), changes in sputum characteristics, and detection of a causative agent.(1)(2)

EBG's: It is a systematically developed statements derived from systematic reviews based on best research evidence of clinical effectiveness which assist in decision making about appropriate healthcare for specific clinical conditions effectively implemented, this guideline may decrease the morbidity, mortality, and costs of VAP in mechanically ventilated patients.(1)

Mechanical Ventilator: Any device used to support, assist, or control respiration (inclusive of the weaning period) through the application of positive pressure to the airway when delivered via an artificial airway, specifically an oral/nasal endotracheal or tracheostomy tube.(3)

Ventilator bundles: VAP bundle, which is derived from the International Health Institute (IHI), bundle is **a package of evidence -based interventions that include**, and composed of the following 4 major interventions: head-of-bed elevation between 30° and 45°; a daily "sedation vacation" and a readiness-to-wean assessment; peptic ulcer disease prophylaxis; deep vein thrombosis prophylaxis.(4)

Endotracheal aspirate (ETA): A common procedure within intensive care units is the suctioning of respiratory secretions in patients who have been intubated or who have undergone tracheostomy. When patients are unable to mobilize their secretions, they may need suctioning of the secretions from the oropharynx and/or trachea to maintain their airway patency .It can also be used for detection of causative agent of VAP.(5)

Endotracheal tube (ETT): It is a small, usually plastic tube inserted into the trachea through the mouth or nose to maintain an unobstructed passageway especially to deliver oxygen or anesthesia to the lungs.(6)

CHAPTER ONE: INTRODUCTION

1.1. Background.

King Faisal hospital Kigali (KFH, K) is the third national reference and teaching hospital with 161 total beds. It has also nine beds on Accident &Emergency and nine beds in Hemodialysis unit. It is a multi-disciplinary specialized hospital built on Saud found 1987 and started operating in 1992. It is located in Gasabo District, Kacyiru Sector Kamatamu Cell, and Bukinanyana Village in Kigali City. It is the first and only Rwandan hospital having international accreditation by CHOSASA. It serves Rwandan population and other patients from East-African region with foreigner's patient requiring specialized care delivered at KFH. Specifically KFH, was created to provide high level of technical expertise than that available in the referral hospitals to both public and private sectors; its role is to ensure that there is a reduction of the number of patients referred abroad.(7)

Intensive Care Unit (ICU) of KFH is located in second flow, front side of the building. It has seven beds well occupied with medical equipment (ICU Beds, monitors, pumps, ventilators, Oxygen and suction apparatus...). The ICU has 24 hours medical and nursing coverage (One Doctor specialist, One General Practitioner (GP) or Post graduate Doctor (PG) per shift and four to five nurses per shift of 12 hours). The ICU has three physicians, 22 professional nurses including four critical care nurses and one Nursing Unit Manager (NUM). The ICU management is made up of doctor the head of unit and Nursing Unit Manager. It has supportive staff including two health care assistants and one administrator assistant. It is one of critical care department located in Per-Operative and Critical Care Services (POCCS), Directorate of KFH.

ICU KFH is a multi-disciplinary busy unit. It admits different adult and pediatric patients from different specialties including (Medical, general surgery, Neuro-surgery, Renal and Cardiac patients). ICU KFH receives acute and chronic patients. In any Hospital, The role of an intensive care unit (ICU) is to monitor, support and treat critically ill and vulnerable patients. For the most scrupulous of care, intensive care units are Human resource consuming. The ratio nurse to patient is strictly recommended as tight as one to one or one-to-two. Patients are still at high risk for infections despite significant advancements in medical technology, which are frequently preventable by following a few straightforward precautions. These patients' lives and deaths are in the hands of the professional healthcare staff.(8)

1.2. Problem statement.

"There is high rate of Ventilator Associated Pneumonia in Intensive Care Unit of King Faisal Hospital"

Problem explanation

According to ICU statistics, the reports from 2014 to 2019 show a remarkable increase of infection rate in ICU KFH. These are justified by average infection rate of 78% in past 6 years.

Table 1 : Overall ICU, KFH infection rate, IPC report 2019

Years	2014	2015	2016	2017	2018	2019
Infection rate	69%	61%	68%	61%	128%	85%

Source: Unpublished data ICU/IPC report 2019

The highest pick of infection rate of 128% in 2018 is explained by several infections on one patient admitted in the unit (Example: Tracheal, urine and blood infections). It is explained also several episodes or recurrence of infections on one patient.

According to ICU 2019 statistics from admission book, among 243 patient admitted in the unit, 231 patients (95%) were mechanically ventilated. Among 231 ventilated patients, 103 of them had tracheal aspirates positive growth (45%) and these samples were taken 48 hours and above post admission. This has motivated to conduct a deep study on VAP incidence rate.

Statistical analysis of consecutive three months from October to December 2019 shows among 77 patients admitted in ICU, 45 were intubated and on mechanical ventilator more than 48 hours. Among 45 intubated patient, 34 had new or progressive chest radiography infiltrate, 41 of them had fever > 38 ºC with 18 positive growth of tracheal aspirates. We find also 35 patients had altered white blood cells (Leukocytosis or Leukopenia), 16 patients had combined all criteria, which gives VAP rate of 36 % (see the following table 2 and more details in table 24).

Table 2: VAP rate in ICU/KFH 2019

VAP(confirmed with all criteria)	Year
	2019
Count (VAP all criteria)	16
% within Year	35.56%
Total	45

Primary data: VAP confirmed cases 2019

1.3. Objective of the study

To reduce VAP incidence rate in ICU /KFH from 36 to 13% within 3 months of intervention.

1.4. Hypothesis

Alternative Hypothesis: ICU clinical staff training reduces VAP incidence rate.

Null hypothesis: ICU clinical staff training will not reduce VAP incidence rate.

1.5. Justification of the project

Healthcare associated infections (HCAI) refer to infections that results to contact with the healthcare system in its widest sense, also called nosocomial infections. It can occur in your own home, to primary care, nursing home care and care in acute hospitals and constitute a major health problem worldwide; in hospitals. They are infections that are developing in a patient who is hospitalized and that were not discovered at the time of admission. WHO reports 7.1 million cases that result in severe morbidity and mortality in hospitalized patients per year. (9).

One of the most prevalent nosocomial infections in patients on mechanical ventilation in the intensive care unit (ICU) is VAP; it occurs earlier during the course of hospitalization 48-72 hours, while contributing to approximately half of all cases of hospital-acquired pneumonia and estimated to 9–27 % of all mechanically ventilated patients.((10)

VAP imposes a significant economic burden and is poorly studied in African context. Patients with VAP are twice more likely to die than those without VAP, and it is associated with significant morbidity and additional health costs. (11).

This pre post intervention study is very important as it will contribute to increase clinical staff knowledge in field of VAP, will increase the compliance rate of Evidence Based Guideline of

VAP preventive measures. The goal of this pre post intervention study is the reduction of VAP. rate, contribute to patient quality of care and finally improve on patient outcome.

1.6. Organization of the dissertation study

This pre and post intervention study is organized into three phases:

Pre intervention phase: The period of 3 months from October to December 2019 was a period of defining and identification of the problem. The problem was initially raised in Annually IPC report of high infection rate in ICU, and high use of strong antibiotics. After several meeting and discussion, the ICU team decides to conduct a quality improvement project on infection rate reduction.

End 2019 and early in 2020 there was a gathering of baseline data then followed by a spread of covid-19 pandemic and we considered this period as neutral phase as there was so many confronting factors. But we went through policies review and guideline review.

End 2020 and Early 2021 was the time to search the root cause analysis of raised VAP rate in ICU/KFH. The entire project followed the 9 steps of scientific problem solving.

Intervention Phase: 2021 after finding the root cause from so many other causes listed by ICU clinical staff, through questionnaire, observation guide, guideline compliance evaluation we find the real root cause was "**Low compliance level of Evidence Based Guideline on VAP prevention**" 55.8% due to lack of training on EBG of VAP preventive measures. Several training conducted from August to September 2021 and some techniques demonstration of VAP preventions measures (I.e oral care with available antiseptic, oral kit including suction brushing, aseptic ETT and tracheostomy suctioning, ventilator exhalation valve cleaning and disinfection,..).

Post intervention Phase: After intervention another period of 3 months (October to December 2021) we went through data collection, staff knowledge evaluation, patients files review, laboratory microbiology analysis of patients report (JEEVA system) and all patient Chest X-ray report in MEDSYNAPSE PACS radiography report. Data coding, data cleaning and data analysis took place also in this post intervention phase.

CHAPTER TWO: LITERATURE REVIEW

Healthcare associated infections (HCAI), also known as nosocomial infections, are significant global health issues that arise from contact with the healthcare system in its broadest definition. They can occur in the patient's own home, in primary care settings, nursing homes, and acute hospitals. They are infections that are developing in a patient who is hospitalized and that were not discovered at the time of admission. WHO reports 7.1 million cases that result in severe morbidity and mortality in hospitalized patients per year. (9).

According to the WHO, HAIs are a serious issue not just in underdeveloped nations but also in highly industrialized nations, like Europe, where they constitute a major cause of high morbidity and mortality.(12) According to the ECDC, there are around 3.2 million instances of HAIs in European Union (EU) nations, and 37,000 fatalities are reported there each year.(13)

Depending on the patient population, VAP is the most common cause of death from HAI, with attributed mortality varying from 15% to 70%. (8).

The most frequent complication for ICU patients is ventilator-associated pneumonia (VAP), which is associated with significant morbidity. A lung infection known as VAP can appear during or after mechanical ventilation and intubation. It is characterized by signs of infection (fever, altered white blood cells counts...), purulent tracheal discharge, along with radiological evidence of pneumonia (new or progressive infiltrate). VAP occurs within 48-72 hours and imposes a significant burden by contributing to more than the half of all hospital-acquired pneumonia.(10)

VAP imposes a significant financial cost. A recent cost evaluation from the USA approximated that the attributable cost of VAP to be $40,144 (95% CI $36,286–$44,220).(14).

Asia-Pacific countries (Australia, Singapore, and South Korea) have the second highest prevalence of VAP, with 16%, followed by Latin American countries (Chile, Colombia, and Mexico), with 13.8%.(15).

The prevalence of ventilator-associated pneumonia was 21.6%, or 9.96 episodes per 1000 ventilator days, according to the Iranian Nosocomial Infection Surveillance INIS. (16).

The observational study was conducted in 7 Polish adult ICUs in Europe. The European Healthcare-associated Infections Surveillance Network was used to conduct VAP surveillance, which revealed ;The incidence of VAP was 8.0%, with density of 12.3/1000 ventilator days.(17)

Ventilator-associated pneumonia (VAP) is poorly studied in African context. In South Africa, prevalence ranges from 10 to 25% in tertiary care health facilities, with some settings reaching 76%. VAP is associated with significant morbidity and increased financial burden, and patients with VAP have been found to be twice as likely as those without VAP to die.(11).

In South Africa, Ventilator-associated pneumonia is a significant issue for mechanically ventilated patients. It has a significant impact on their illnesses and the outcomes that lead to death. (18).

Rwanda is one of East African countries. It counts 48 public hospitals only four National Referral and University Teaching Hospitals NRH/UTH which have Intensive Care Units. Those hospitals are CHUB, CHUK, RMH, KFH, K. (7) Catheter-associated urinary tract infections (CAUTI) are the most common HCAI, accounting for 34%, followed by surgical site infections, central line associated blood stream infections (CLABSI), and ventilator-associated infections (VAP). (9)

In Rwanda, the report of IPC at KFH has revealed that among 231 ventilated patients in ICU, there were 103 tracheal aspirates positive growth and this represent 45 % of VAP rate. These data was collected from ICU admission book, microbiology report and infection prevention & control report of KFH 2019. However there is no published data on Ventilator Associated Pneumonia in Rwanda.(19)

2.1 VAP incidence rate calculation.

VAP prevalence and incidence are difficult to calculate since some definitions are subjective and unspecific. Clinical surveys indicate that 10-20% of ventilated cases will develop VAP. VAP is a lung infection that occurs in a patient who has been mechanically ventilated for >48 hours and is defined by clinical, radiographic, and microbiological criteria. It has been demonstrated that 55% of VAP cases can be suppressed when evidence-based guidelines are respected.(20)

VAP incidence rate calculation: Number of cases with VAP/Total number of patients who received MV(>48hrs) x 100 = VAP rate per 100 patients.(21)

2.2 Risk factors and pathogenesis of VAP

The use of mechanical ventilation is clearly a risk factor for pneumonia that develops in hospitals. Literature adds aspiration, decrease of level of consciousness, extensive patient management and transportation, and chronic lung disease on top of this. In addition to all of these, VAP can also be caused by hematogenous dissemination, pleural space infection that spreads, and breathing in polluted air. Pathogens primarily enter the lower respiratory tract through aspiration of excretions that include germs (from oropharynx or stomach). The upper airway microbiota may contain pathogens that cause VAP, or they may become exogenous after a stay in the hospital. In the first five days of ventilation, the risk of VAP rises by 3%, in the following five days by 2%, and in the following ten days by 1%.(22)

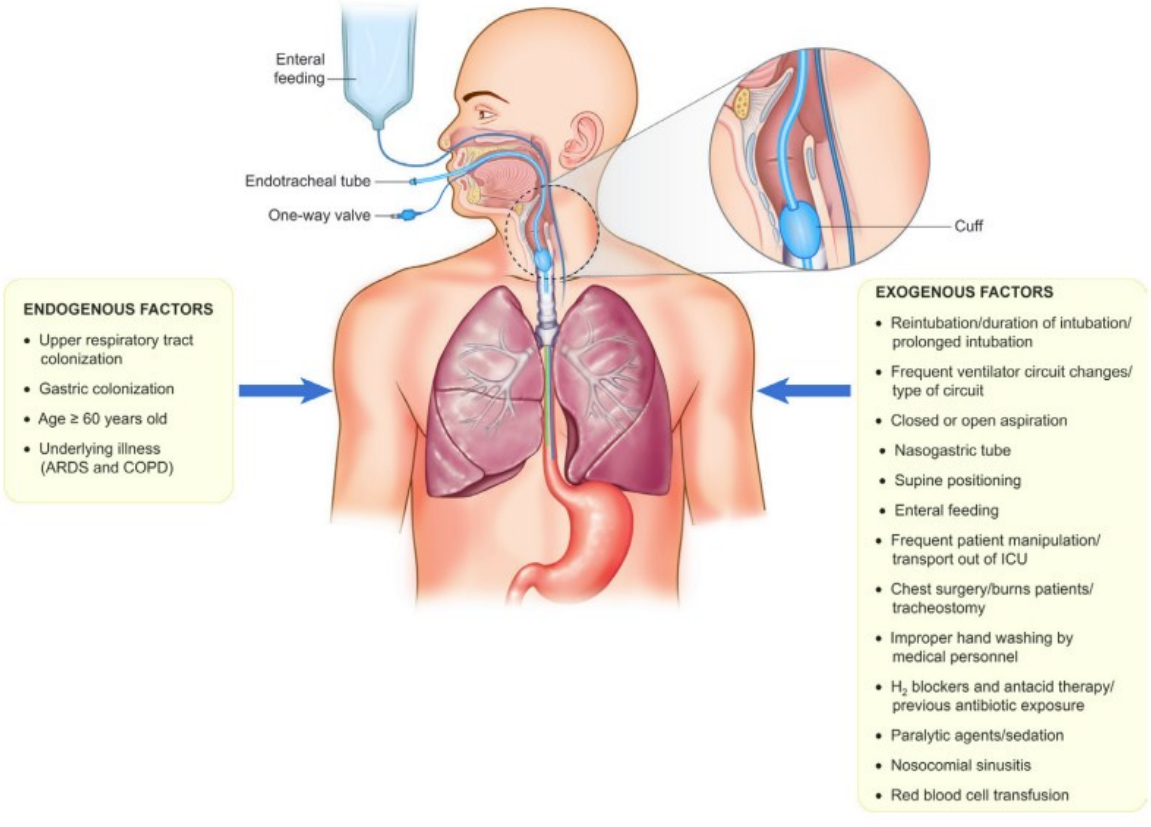

Figure 1: Main endogenous and exogenous possible risk factors for VAP.

The VAP is a type of nosocomial pneumonia that is associated with higher morbidity and mortality. Understanding the prevalence, incidence, and risk factors is essential for implementing preventive measures and lowering mortality rates among these patients.(23)

CHAPTER THREE: METHODOLOGY

3.1 Design

This pre post interventional study was designed following scientific problem solving steps and summarized as follow:

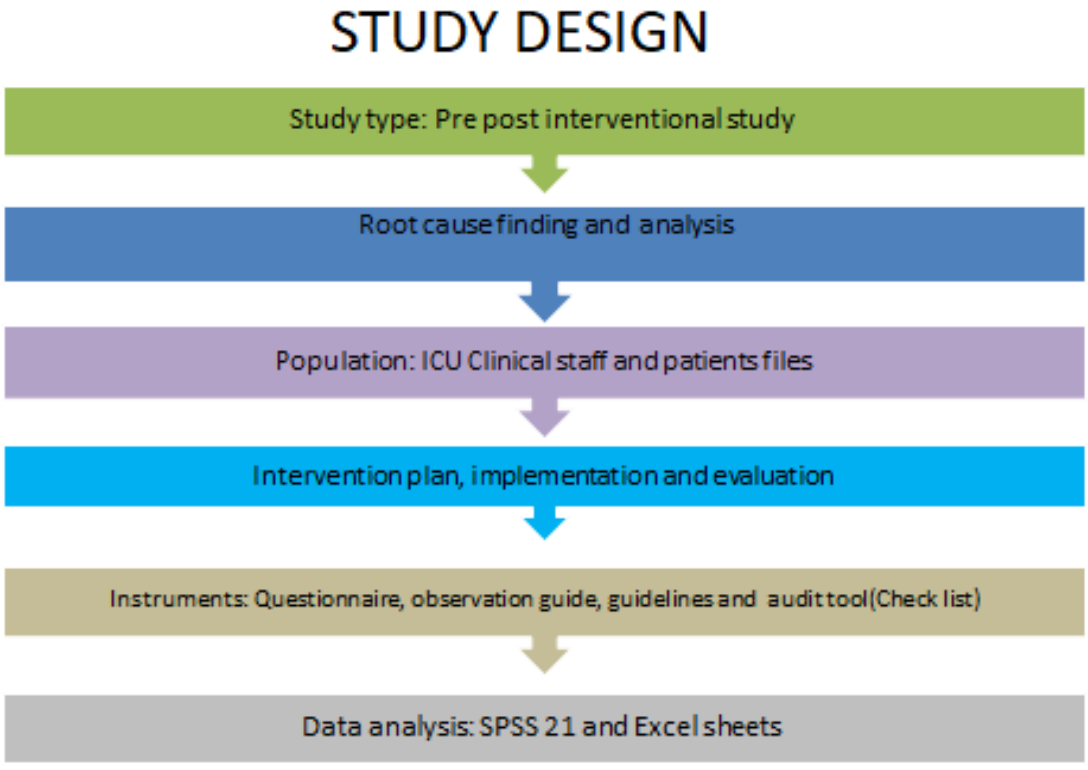

Figure 2: Figure shows the study design.

A pre-post interventional study compares the occurrence of an outcome before and after the implementation of a specific intervention. A before-and-after study (also known as a pre-post study) assesses outcomes in a group of participants before and after the introduction of a product or other intervention. Any differences in outcomes are attributed to the product or intervention. This study has two comparison groups and is classified as quasi-experimental designs. The two periods was considered:

1st period 2019 (3 months: October, November and December).
2nd period 2021 (3 months: October, November and December)

3.2 Root cause analysis

The information on root cause was collected in order to gather all ideas, suggestions related to VAP causes in ICU. It was free explanation, self-reporting trough piece of paper, from morning reports and ICU general meeting. The collecting possible root causes & opinions we used also literature review, brainstorm, interview and focus group discussions

3.2.1 Baseline data collection

The initial data was found in IPC report of 2019 where it was showing high infection rate in ICU KFH and VAP rate was 45%.

Using check list after consulting patients files, admission book, laboratory microbiology report and verification of CXR of all intubated patients the VAP rate was 51.7% but calculated on suspected cases of all new or progressive infiltrate.

Considering the total intubated patients admitted in 2019 which was 77, and those under mechanical ventilation for a period more than 48 hours were 45 in which 16 of them had all VAP criteria. These give the final VAP incidence rate of 36% considered as baseline data.

3.2.2 Sample size

All 77 patients admitted in late period 2019 (3 months: October, November and December).

But only 45 patients were intubated and on mechanical ventilation more than 48 hours.

Inclusion criteria - Patients intubated and mechanically ventilated.
-Patients intubated more than 48 hours
-All patients more than 1 month of age

Sample technique: all patients fulfilling the inclusion criteria

Data collection method: Patients files review and VAP confirmation criteria was analyzed and checked one by one:

- Chest X-ray of patients (New or progressive infiltrates)
- Altered body temperature (Fever or Hypothermia)
- Altered white blood cells counts (Leukopenia and Leukocytosis)
- Microbiology report (ETA positive growth)
- A change in sputum characteristics was analyzed but was not documented for all patients and is very subjective reason why we have considered microbiology report.

3.2.3 Identification of root cause

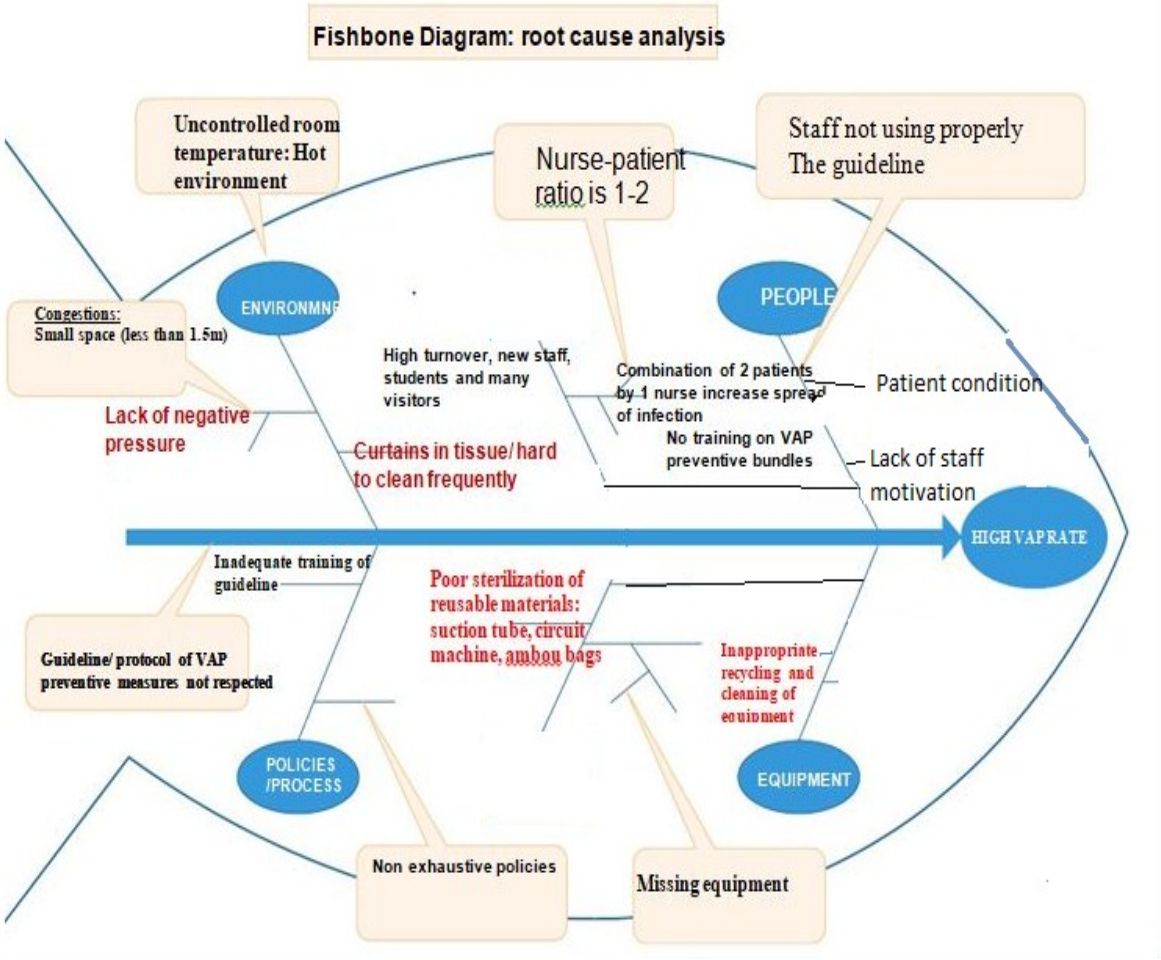

Figure 3: Fishbone diagram from KFH-ICU Brainstorming/self-reporting July 2020.

The information from figure 3 was collected in order to gather all ideas, suggestions related to VAP causes in ICU. It was free explanation, self-reporting trough piece of paper, from morning reports and ICU general meeting. The collecting possible root causes & opinions we used also literature review, brainstorm, interview and focus group discussions.

This study analyzed four aspects which enter in root cause and verified each aspect separately by consulting literatures and ICU expert. Several meetings and debates held in ICU and conclusions made for those aspects. The team of 13 nurses among the 4 nurses specialist in critical care had discussions, observation, policies review to come out with final root causes.

Table 3: Analysis of possible causes of VAP in ICU/KFH

SOURCE OF INFORMATION	INFO TO BE COLLECTED
People	-Patient condition -Aseptic technique not respected -No training or lack of knowledge on VAP bundle/ guideline -Many visitors in ICU -Staff shortage (ratio Nurse/Patients) -Lack of Staff motivation
Equipment	-missing equipment -Inappropriate cleaning /sterilization of reusable equipment
Policies	Guideline on VAP prevention not well respected
	Policy on Admission criteria not respected
	Policy on early extubation not respect
	Non exhaustive policies
Environment	Small space Hot environment Lack of air aspiration/negative pressure. Curtains separate the beds

Source: KFH-ICU Brainstorming/self-reporting June-July 2020.

3.2.4. Justification of root cause.

In order to verify each suggested causes of raised VAP incidence rate in ICU/KFH, we have collected evidences using different tools: Pareto diagram, Tally sheet, check list, questionnaire and literature review.

3.2.4.1 Peoples aspect in root cause analysis (RCA).

In the following paragraph there is suggested cause of raised VAP in ICU/KFH nurses voluntary self-reported. We have considered only nurses because they are the one who perform patient ETT and tracheostomy suctioning, with ventilator equipment cleaning and recycling most of the time.

Considering nurses views, most of them have mentioned measures of standards on VAP prevention. Clinical evidence indicates that implementing of each element of VAP bundle reduces the risk mortality and morbidity of patients under mechanical ventilation.(24)

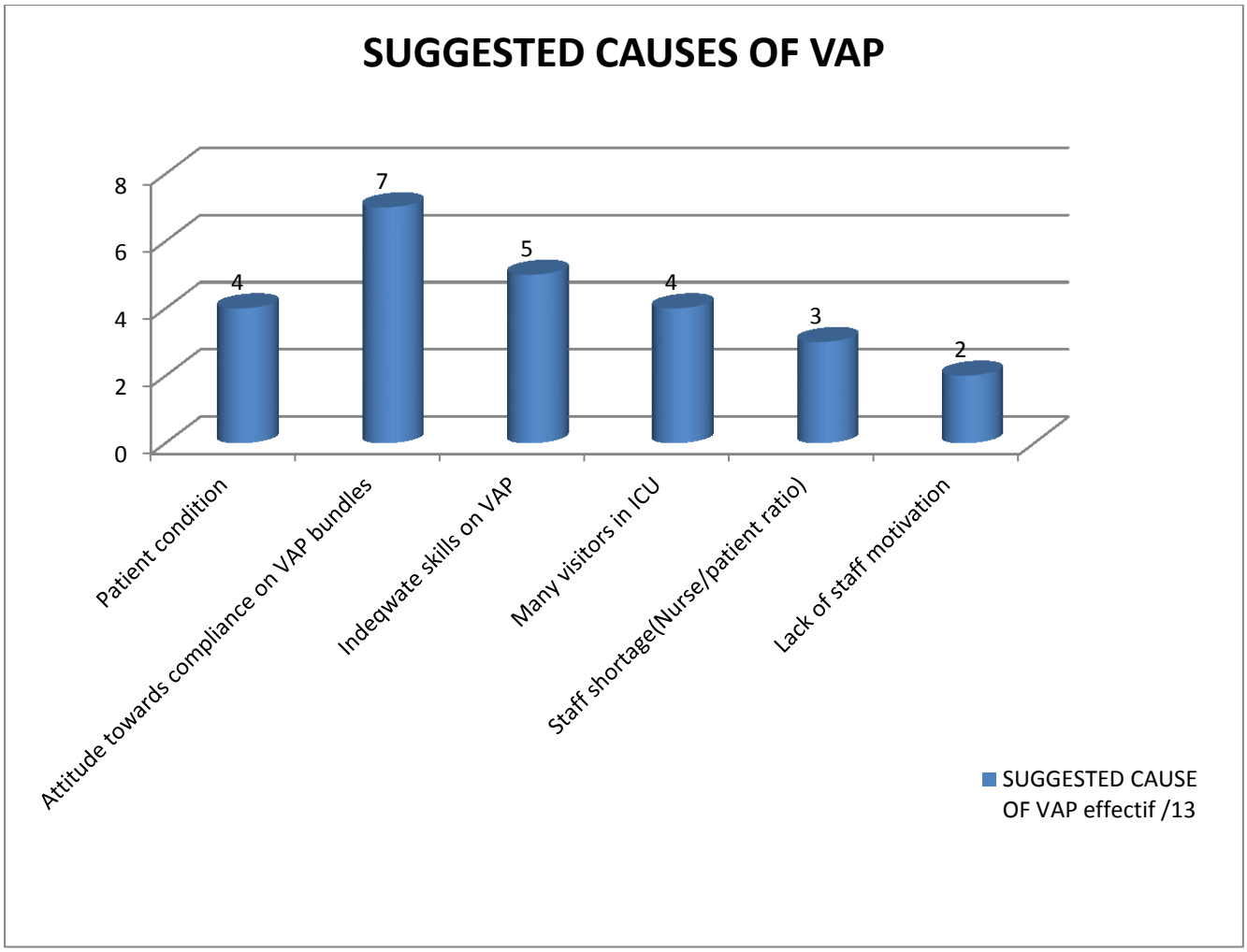

Figure 4: Showing suggested causes (People aspects) of VAP in ICU KFH,K July 2020

Brainstorming and self-reporting of 13 Nurses working in ICU during morning report in three consecutive days have given their idea on the cause of high incidence rate of VAP. 7 of them (53.8%) have mentioned attitude toward compliance on EBGs which has trigged the deeper investigation of the mentioned guideline on VAP preventive measures.

3.2.4.2 Equipment and materials aspect (RCA)

The equipment and materials are essential in VAP prevention. Nurses and other clinical staff should be aware of those equipment's needed in VAP prevention for proper cleaning, disinfection, recycling, ordering and supply. There was some missing equipment as indicated in guideline.

Table 4: Equipment and Materials aspect in (RCA)

Equipment	Observation	Conclusion
Missing equipment • Cuff Manometer • Oral care kit • Closed/inline suction catheters • ETT with subglottic aspiration	 Missing Missing Missing Missing	 Retained √
Cleaning & recycling of reusable materials ✓ Suction tubing ✓ Suction bottles	 Well sterilized Well cleaned	 Rejected
Single use items (Suction catheter, HME filter, catheter mouth, ETT, Tracheostomy tube)	Available and sterile	Rejected
Sterile resuscitation bags	Not sterile	Retained √

The above table 4 in observation study shows that they are some missing equipment which is crucial in VAP prevention bundle. Conclusion Colum indicate that if retained will be considered in cause of increased VAP rate in ICU. If rejected it means the equipment's were available and well sterilized

3.2.4.3 Policies/process and procedures (RCA)

There are many policies and procedures involved in VAP and other hospital acquired pneumonia prevention. Among them some policies were discussed and analyzed.

Table 5: policies/process and procedures in RCA

	Policies	Observation	Compliance	Conclusion
Policies/ Procedures	Guideline on VAP prevention not well respected	Not respected No audit done	PC	Retained √
	Policy on Admission criteria not respected	Respected	C	Rejected
	ETT suction Aseptic technique not respected	Not well done	PC	Retained
	Non exhaustive policies ➢ Extubation policy(08 :00 am to 03:00pm) ➢ Admission infection surveillance policy ➢ Oral care with antiseptic	 Respected Not done Not well done	 C NC NC	 Retained √ Retained √ Retained √

Legends: C= compliant, **PC**= Partial compliant, **NC**= Non-compliant
Red color indicates the procedure highly exposing to increment of VAP rate.

In the previous tables 6, some policies are not compliant and this has an implication in increment of VAP rate in ICU KFH. Other policy like extubation policy is compliant but can contribute to increment of VAP rate because it can compromise extubation time when the patient meets the criteria. These three policies were named as non-exhaustive policies.

3.2.4.4 Environmental aspect (RCA).

The environmental aspect is very important in RCA of infection rate in ICU especially in VAP cause analysis. The temperature, humidity, Small congested space and Curtains which separate the beds were analyzed to find out the real root cause of VAP in ICU KFH. The observation, Temperature & Humidity observation chart with measurement of distance between ICU beds have given the information detailed in the following table.

Table 6: Environmental aspect in RCA.

ENVIRONMENTAL FACTORS					
	Listed factors	**Verification**	**Discussions**		**Conclusion**
Environment	Small congested space Hot environment Lack of air aspiration/negative pressure. Curtains which separate the beds	ICU Standards Temperature Checklist (Curve) Observation Observation guide	Yes Yes Yes Yes	High risk No risk Minimum risk High risk	Accepted √ Not accepted Not accepted Accepted √

One of the first assessment to make during the first phase of this study is the environmental space temperature and humidity as shown in Standard 170 (ventilation of healthcare facility) requires temperatures ranging from 68°F to 75°F dry bulb (DB) (20°C to 24°C). KFH,K ICU temperature ranger between 20^{o}C to 23^{o}C. There is a wide variation in suggested temperature from 16 °C to 25 °C in general ICUs (27).There no relationship between KFH,K ICU temperature and raised VAP rate. Lack of air aspiration/negative pressure can contribute to overall reduction of dust and other small particles in ICU but no evidence in reduction of VAP rate as most of infection are caused by contact germs.

Small congested space and Curtains which separate the beds contribute to infection dissemination in ICU but the KFH management agreed to consider them in renovation phase of ICU in few coming years.

3.2.4.5 Evidence Based Guidelines (EBG's) in RCA

EBGs are a collection of standards based on best research evidence for best practices that were developed through a systematic review. This guideline was adopted by KFH and belongs to list of IPC guidelines. It was chosen and analyzed in this study because it contains three aspects detailed in fishbone (People, policy and equipment). It was also mentioned by ICU nurses brainstorming at high percentage 53.8% (see graph 1). The following table summarizes the compliance level of EBG's on VAP preventive measures. We used the scale from 1 to 3 to verify the implementation levels.

Table 7: Evidence based guidelines of VAP prevention (EBGs)

	Criteria	3	2	1	OBS %
1	Head of bed elevation 30-45/ semi seated position		PC		51.1
2	Oral care with antiseptic agent available			NC	30.6
3	Stress ulcer prophylaxis	C			82.1
4	Deep Venous thrombosis (DVT)prophylaxis	C			81.5
5	Daily sedation assessment and spontaneous breathing trials(STB)			NC	36.1
6	Alcohol-based hand rubbing and washing as per policy	C			83.0
7	Aseptic technique when suctioning via tracheostomy and ETT		PC		54.4
8	Single use of suction catheters/tubes	C			81.7
9	Clean the suction tubing with sterile water	C			82.2
10	Change of tracheostomy stoma done aseptically	C			81.0
11	Appropriate use of PPE	C			80.8
12	Early extubation whenever possible			NC	27.1
13	Change of suctioning tubing /bottles between use per shift	C			80.9
14	Change of Ventilator tubing every 7 days			NC	34.6
15	Use of Oral intubation preferably as opposed to nasal	C			81.6
16	Use of appropriate inflated cuffed ETT or Tracheostomy tube (>20 cmH2O) controlled by manometer			NC	19.2
17	Appropriate cleaning and disinfection/sterilization of reusable suctioning equipment	C			80.4
18	Sterilize resuscitation bags, clean nebulizer kits between use and keep dry			NC	26.5
19	Keep equipment dry and clean to prevent microbial contamination (including clean intubation).		PC		50.0
20	Use of tubes (ETT,Tracheostomy) with Subglottic aspiration			NC	0.0
21	Use of closed circuit aspiration system			NC	26.4
	AVERAGE				**55.8%**

Source: Primary data shows compliance rate of EBG's early 2020 (pre- intervention)

Legends: **1**= **NC** Non-compliant 0-49% (Red color); **2**= **PC** or Partial Compliant 50% -79% (Yellow color) 3= **C** or Compliant 80%-100% (green color).

Using the above table 8, audit tool of Evidence based guideline of VAP prevention, the overall implementation level of the tool is below 50 % (10 compliant out of 21 criteria: (10/21) x 100= **47.6 %**). The overall average of compliance is **55.8%.**

Clinical evidence recommend that implementing of each element of VAP bundle decrease the mortality and morbidity of patients undergoing mechanical ventilation(Jain S. *et al.*, 2017).This pre and post interventional study is also descriptive because it will describes the compliance level of EBG on prevention of VAP(18).

Having a policy in place and in our files is clearly insufficient to reduce VAP incidence rates but monitoring, evaluation bundle compliance, as well as implementing best practices to ensure high compliance, are required to see a decrease in rates.(28).

Table 8: The selection of final root cause of VAP in ICU/KFH

	Root cause	**Team Decision**
1	Staff shortage	Accepted
2	Attitudes toward EBG on VAP preventive bundle and its poor compliance level due to lack of training	Accepted
3	Missing equipment and unsterile resuscitation bags	Accepted
4	Non-exhaustive policies	Accepted
5	Small and congested space with Curtains which separate the beds	Accepted

"**Low compliance level of Evidence Based Guideline on VAP prevention**" **55.8%** whereby target of compliance rate should be all the time more than 80%.

The low compliance level of EBG covers number three and four in the previous table of root cause, this guideline includes also policies and talks about equipment needed in prevention of ventilator associated Pneumonia. It contains also three aspects detailed in fishbone (People, policy and equipment).

Few staff (four out of 32) trained on EBG of VAP preventive measures in 2019 (12.5% get training at school). No training at all delivered in KFH/ICU on VAP preventive measures.
The successive surveys, and several studies have revealed a possible impact of the VAP bundle campaign both on respiratory care of ventilated patients and on the prevalence of VAP in Belgian and global ICUs, and encouraged them to pursue the guidelines.
It should be noted that VAP is now considered as a performance indicator in the United States and some other countries. The National Healthcare Society Network reported a significant reduction in the incidence rate of VAP attributed to a multi-variable infection control program and its effective implementation.(29).

Each element of EBGs of VAP preventive bundle contribute to the reduction of VAP incidence rate and reduction of morbidity and mortality related to the sepsis in ICU.
There was also other causes related to environmental and infrastructural aspect but the hospital has accepted to consider them during ICU renovation in future. The recommendations were given to the hospital management.

The guideline of Australian College of Critical Care Nurses (ACCCN) recommends a minimum ratio of 1:1 for ventilated and other critically ill patients, and a ratio of 1:2 for nurse patients with lower acuity (clinically determined). In patients requiring complex management, higher ratios may be required.(30).

3.3. Interventions

The following are possible solutions that can be used to address the poor compliance rate of Evidence Based Guideline on VAP prevention.

- -Staff training on EBG on VAP preventive measures.
- -Ensure adequate staffing (nurses) in ICU

EBGs were created in an order to find a solution to the VAP problem. These recommendations include several evidence-based strategies that have been shown in the literature to reduce ventilator-associated pneumonia and improve patient outcomes. There are 21 VAP prevention strategies, which are divided into 10 physical strategies, 3 positional strategies, and 8 drug strategies.(31).

VAP, on the other hand, is preventable, and EBGs for VAP prevention have been shown to reduce the incidence and burden on patient outcomes on a global scale. Knowledge and adherence to evidence-based VAP prevention guidelines would reduce the risk of developing VAP as well as morbidity and mortality in mechanically ventilated ICU patients.(32)

As a result, the nursing shortage is a burden, and critical care nurses are in high demand in Rwanda and around the world. The few remaining critical care nurses must constantly update their knowledge and scientific evidence on the many problems that exist in the intensive care unit, including VAP. Based on the root cause, in the following phase, discussion with different ICU teams on strategies to reduce VAP by increase compliance rate of EBGs preventive measures is as follow.

3.3.1 Comparison of possible interventions

Based on comparative analysis of 4 aspects: impact, Cost, time, feasibility, the two selected interventions were analyzed separately in table 10, and the final result is as follow:

Table 9: Comparison of possible interventions

Alternative solutions	EVALUATION CRITERIA (5=Good; 1=Bad/)				
	IMPACT	**COST**	**TIME**	**FEASIBILITY**	**TOTAL**
Staff training on EBG on VAP preventive measures	3	5	5	5	**18**
Ensure adequate staffing(nurses) in ICU	4	2	2	3	**11**

Source: Primary data Comparison of possible interventions ICU/KFH

The above table 10 shows high aggregate of staff training on EBG on VAP preventive measures after computation of aspect criteria score.

3.3.2. Selection of Best strategy/ Best intervention.

Reference from the tables 10 on comparative analysis, the best intervention of VAP reduction is: "**Training of all staff on Evidence Based Guidelines of VAP preventive measures**" because it scores 18/20. The comparative analysis suggests the highest score to be chosen.

In service staff training on VAP preventive measures during the implementation phase is beneficial for staff capacity building, patient advocacy and increase compliance level of EBG.

The high incidence rate of VAP and the poor prognosis of VAP have made their prevention an international goal, and the rate of VAP has become an indicator of the quality of health care.(33)

To prevent VAP, nurses must be aware of prevention strategies and incorporate them into their routine clinical activities. Nurses play a critical role in non-pharmacological preventive interventions that are directly related to external risk factors. However, despite recommendations based on evidence, the application of these measures remains insufficient and various studies show heterogeneous practices and insufficient compliance with the guideline.(34). This also is the case of ICU KFH where by the compliant rate of EBGs on VAP preventive measures was **55.8%** and the aim of this intervention is to increase its compliance level above 80% in order to reduce VAP incidence rate in ICU/KFH, K.

3.4. Measure of indicators

Three main indicators were used in this pre post interventional study to evaluate the results of the implementation of project. The first is increase knowledge on VAP preventive measures, the second increase the compliance rate of EBG and the final outcome indicator is reduction of VAP incidence rate in ICU/KFH.

Table 10: Measure of indicators

	Indicator	Outcome definition
1	Increase knowledge of nursing staff on VAP prevention by training.	**Training at 100%**
2	Increase compliance rate of EBGs of VAP preventive measures	**compliance rate > 80%**
3	VAP rate reduction of 50%	**From 36% to 13 %**

Source: Primary data: Measure of indicators

3.5 Data analysis procedure

After gathering the information on root because analysis and level compliance on evidence based guideline on VAP prevention, all data were entered, coded and analyzed using SPSS (Statistical Package for the Social Sciences) software. SPSS 21 was also used for additional analysis (Frequency distributions, cross-tables, overall presentation of all data). Some statistical tests were also carried out. Excel sheet was also used to generate tables and graphs.

Age, sex, years spent working in an ICU, and level of training were used to evaluate the demographic data using descriptive statistics and cross tabulation.

ANNEX 1. Evidence Based Guideline on VAP preventive measures used to measure the compliance rate.

ANNEX 2. Questionnaire of ICU staff knowledge on VAP preventive interventions. Level of education, experience and VAP preventive measures of ICU staff.

ANNEX 3: Ethical clearance from institution board review and from KFH,Kigali

ANNEX 4: Example of VAP data collection for 2019 and 2021 used to gather all information related socio demographic characteristic of patients, Status, diagnostic, duration in ICU and VAP diagnostic criteria. Every criteria was coded as "YES" if positive or available, and "No" if negative, and "NA" if not available.

ANNEX 5: GANTT'S CHART for activities time table

ANNEX 6: Plagiarism, similarity and originality index report

Annex 7: Paired Samples Statistics and Paired Samples Test.

3.6. Ethical consideration

In this pre-post interventional study there was no contact with the patient, the procedure or treatment was not affected, we audited the patient records. There was only education and improvement of patient care. The checkup of lab result in JEEVA laboratory system (WBCs and Tracheal aspirates microbiology report) and CXR checked in MEDSYNAPSE PACS radiology system after an approval from KFH ethic and research committee and CMHS institutional review Board (IRB) from University of Rwanda. The questionnaire and audit tools filled by ICU clinical staff has agreed to participate voluntary in the study, in the trainings, and being part of the project as it was a team work activity. Staffs have signed on training list.

CHAPTER FOUR: RESULTS

The principal objective of this pre post interventional study was to reduce VAP rate in ICU/KFH. The objective was achieved because the VAP rate in 2019 was around 36 % but after intervention "Training of ICU staff on EBG on VAP preventive measures" VAP rate become 10% in 2021 after considering all criteria not only number of intubated patient more than 48 hours and positive microbiology of tracheal aspirate. It is the result of training, education and demonstration of EBGs to ICU clinical staff (Nurses, HCA, Physiotherapist and Doctors).

The following tables and figures demonstrate the result of pre-post interventions studies.

4.1. Socio Demographic characteristics (ICU Nurses)

4.1.1Age of nursing staff (ICU and HDU)

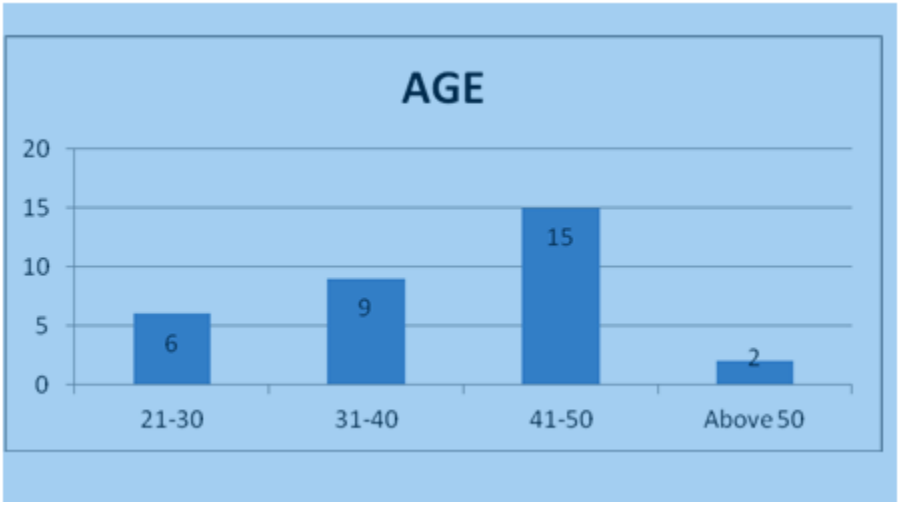

Figure 5: Primary data ICU Nurses October to December 2021

The above graphic shows the modal age group is between 41 to 50 years and two nurses have above 50 years. The youngest age group is between 21-30 years. This means ICU/KFH has the young staff. People are changing tastes and behavior as they get older.

4.1.2. Gender of nursing staff

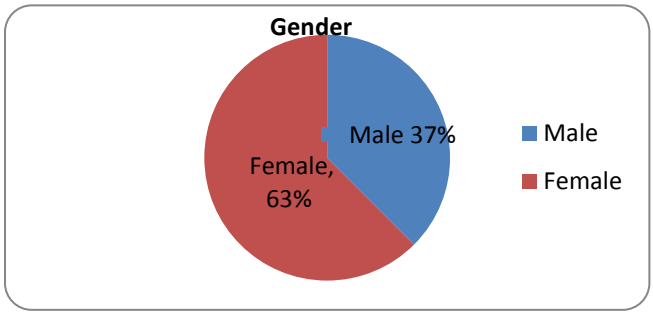

Figure 6: Primary data ICU Nurses gender October to December 2021

The above diagram shows also ICU KFH have predominant females 20(62.5%) compare to 12 males (37.5 %.). Gender is very important in demographic characteristics of respondent in any given study. It is crucial also to interview both male and female to avoid gender inequalities and discrimination. The presence of gender differences in personality traits, as well as cross-cultural variation in gender differences for a given characteristic, may be evidence that gender complementarity or differences between the sexes are influenced by origin culture or societal roles.

4.1.3. Working experience

Table 11: ICU Nurses working experience October to December 2021

EXPERIENCE	Frequency	Percent
Below 1 year	1	3.1
1-5 years	11	34.4
6-10 years	10	31.3
Above10years	10	31.3
Total	32	100.0

The above table12 shows that more ICU nurses have experience above 5 years 62.5 % but only 37.5% have experience less than 5 years with only 3.1% less than 1 year. It is important to know different staff working experience because with experience you gain more skills and ability. It was demonstrated that the newly employed staff did get training on VAP.

4.1.4. Nurses training on EBG on VAP preventive measures

Table 12: ICU Nurses training on VAP preventive measures 2019-2021

	2019		2021	
Training	Frequency	Percent	Frequency	Percent
No	28	87.5	1	3.1
Yes	4	12.5	31	96.9
Total	32	100.0	32	100.0

The data in above table 13 shows that 31 nurses (96.9%) in 2021 from 12.5 % in 2019 were trained on EBGs for VAP preventive measures. Only one staff 3.1% didn't get any training on VAP preventive measures. This is the result of project intervention.

4.1.5..Level of education for ICU Nurses (Degree)

Table 13: ICU Nurses training on VAP preventive measures 2019-2021

LEVEL OF EDUCATION	Frequency	Percent
A1	20	62.5
A0	7	21.9
Masters	5	15.6
Total	32	100.0

The above table 14 shows 20 nurses (62.5%) have advanced Diploma in General Nursing and 5 (15.6%) have Master's Degree in Nursing this means three in critical care& trauma, one in Pediatric Nursing and One in Renal Nursing. Seven nurses (21.9%) have Bachelor's degree.

4.1.6. Patients Gender both years combined (2019-2021)

Table 14: Gender of ICU patients intubated > 48 hours 2019-2021

GENDER	Frequency	Percent
Females	39	52.7
Males	35	47.3
Total	74	100.0

The table 15 shows the gender of 74 patients participated in this pre-post intervention study, there were 52.7% of females patients compare to 47.3% of male both years combined.

4.1.7. Patients Gender in separate years (2019-2021)

Table 15: Gender of ICU patients in separate years 2019-2021

Year	Gender		Total
	Females	Males	
2019	22	23	45
2021	17	12	29
Total	39	35	74

The above table 16 shows in 2019 there were more males patients 23 than females patients 22 but in 2021 females were 17 compare to 12 males.

4.1.8. Age of patients

Table 16: Descriptive statistics age/gender of all ICU intubated patients 2019 and 2021.

Gender	Mean	N	Std. Deviation	Minimum	Maximum
Female	31.81	39	26.85	0.08	81.00
Male	42.85	35	23.63	0.20	85.00
Total	37.03	74	25.81	0.08	85.00

The above table 17 shows the mean age of females have 31.8 years (≈32years) where by males have 42.8 (≈43 years) and the overall total mean age is 37 years. The maximum age was 85 years for males and 81 years for females. The minimum age was 1month (0.08 year) female and ≈2months (0.20 years). To conclude on the above table, in this pre-post intervention study we had pediatric and adult patients with males and females in different years.

4.2. VAP indicators and VAP rate

In this pre post interventional study, we analyzed different measures and factors that contributed to reduction of VAP incidence rate in ICU KFH. Several interventions on VAP reduction was discussed in different studies but one most studied in University teaching Hospital of Kigali (UTHK) was Oral care as a critical intervention that manages the accumulation of oral pathogens as a comfort measure and not a vital intervention to save lives.(35)

Table 17: All ICU admissions October to December 2019 and 2021

YEAR 2019			YEAR 2021		
Months	**Frequency**	**%**	**Months**	**Frequency**	**%**
October	21	27.3	October	21	28.7
November	34	44.1	November	31	42.4
December	22	28.5	December	21	28.7
Intubated > 48hrs	45	58.4	Intubated > 48hrs	29	39.7
Total	**77**	**100**	**Total**	**73**	**100**

The table 18 shows the total admission of three consecutive months considered as period of research. In 2019 as baseline year the total admission in three months were 77 while in 2021 were 73.

The total patients intubated > 48 hours in 2019 is 45 (58.4 %) compare to 29 (39.7%) in 2021. Only intubated patients more than 48 hours are 74 out of total patients 150, considered as Sample selected in this pre-post intervention study (both years combined). VAP is defined as pneumonia occurring 48 to 72 hours or more after endotracheal intubation and described by the presence of a new or progressive infiltrate, signs of systemic infection (altered body temperature, impaired white blood cell count), changes in sputum properties and detection of causative pathogen.(1)

It is obvious also that in 2021, the number of intubated patients were reduced comparatively to those in 2019. This also is a success of this study best intervention, because any patient who is mechanically ventilated is at risk for VAP.(23)

In the following tables we will be discussed on the real VAP definition considering its diagnostic criteria.

4.2.1 New or progressive infiltrate combined 2019-2021

Table 18: Primary data all new or progressive infiltrates (CXR) 2019 and 2021

Infiltrate on CXR	Frequency	Percent
NO	28	37.8
YES	46	62.2
Total	74	100.0

The table 19 demonstrates all Chest X-ray (CXR) suggestive of Pneumonia taken to intubated patient lasting more than 48 hours in ICU. This is the first criteria to confirm VAP. The table shows 62% of all intubated patients have CXR showing new or progressive infiltrates, and 37.8% didn't have an infiltrate on their CXR images. The further description will analyze how many patients having VAP among the total 74 patients.

4.2.2 Fever comparison 2019-2021

Table 19: Primary data all altered body temperature (<35 and > 38ºC) 2019 and 2021

Fever		Year				Total
		2019		2021		
		Effectif	%	Effectif	%	
	Yes	41	91.1	15	51.7	56
	No	4	8.9	14	48.3	18
Total		45	100	29	100	74

Altered body temperature is the major signs of any infection or sepsis in human being. The table 20 shows that in 2019, 91.1% of all intubated patients had fever, while in 2021, 51.7% had fever. It means there was also a good improvement in infection indicators after intervention.

4.2.3 White Blood Cells (Leukocytosis or Leucopenia) 2019-2021

White blood cells (WBCs), also named leukocytes, are cells found in the blood, lymphatic system, and tissues and are a principal part of the body's immune system. They help to protect against body infections and also play a lead in inflammatory response and allergic reactions.

Table 20: ICU Primary data all altered WBCs count in 2019 and 2021

Leukocytosis or Leucopenia		Year		Total
		2019	2021	
	Yes	35	16	51
	No	9	13	22
	Missing	1	0	1
Total		45	29	74

The above table 21 shows in 2019; 35 patients out of 45 had altered WBCs count compared to 16 out of 29 in 2021.

The VAP is diagnosed by signs of infection (fever, altered white blood cells counts..) purulent tracheal discharge, along with radiological evidence of pneumonia (new or progressive infiltrate) and positive growth of endotracheal aspirates cultures (ETA) or bronchoscopic sampling , broncho-alveolar lavage and protected specimen brush (PSB).(36)

4.2.4 Microbiology positive Endotracheal Aspirates 2019-2021

Table 21: ICU Primary data Endotracheal aspirate (ETA) positive growth 2019-2021

Positive tracheal aspirates		Year		Total
		2019	2021	
	Yes	18	8	26
	No	11	14	25
	Missing	16	7	23
Total		45	29	74

The table 22 on microbiology report shows, on total of 29 sample taken 18 (62.1%) were positive in 2019 and 8 (36.4%) in 2021. Positive tracheal aspirates surveillance cultures have been used to descried the microorganisms responsible for ventilator-associated pneumonia (VAP) in ICU patients for 3 decades(37).

If we compute VAP rate using ventilated patient to the microbiology report as it was used to be done by IPC, KFH the VAP rate would be 18/45(40%) in 2019 and 8/29(27%) in 2021 which gives significant reduction in VAP rate. No missing data considered.

4.2.5 VAP confirmed with all criteria on pneumonia suspects case only

Table 22: ICU Primary data VAP rate considering all studied variables 2019-2021

VAP(confirmed with all criteria)			Year		Total
			2019	2021	
	Yes	Count	15	3	18
		% within Year	51.7%	13.6%	35.3%
	No	Count	14	19	33
		% within Year	48.3%	86.4%	64.7%
Total		Count	29	22	51
		% within Year	100.0%	100.0%	100.0%

In above mentioned table 23; Fifteen patients out of 29 pneumonia suspect cases (Positive CXR result) have all four combined criteria which gives 51.7% in 2019 before all ICU staff training on EBG for VAP preventive measure compare to three patients having all four criteria, out of 19 patients in 2021 which gives 13.6% and this confirm the success of the intervention.

But this indicator is calculated on 51suspect cases of pneumonia only. According to many researchers and articles, there is no unique clinical criteria used to confirm alone VAP.(38)

In this pre and post intervention study we used 4 criteria for VAP diagnosis as it is in Clinical Pulmonary Infection Score (CPIS) score. The patients selected were those who were intubated for more than 48 hours. New or progressive infiltrate which was evaluated by ICU medical doctor's team in Medscape patient imaging system. WBCs <4,000/mm^{-3} or >11,000/mm^{-3} also verified in patient files and NAPIER/JEEVA system, Fever above 38ºC and hypothermia < 35 ºC (Axillary temperature) and finally microbiology report of Endo tracheal aspirates (ETA).

In the following table 24 and figure 4, all cases combined with all variable /criteria for VAP confirmation out of Mechanical Ventilated patients the VAP rate in 2019 was 35.56%(36%) in 2019 and 10.34(10%) in 2021. This confirmation discussed with ICU clinical team and statistician.

Having all 4 variables positive together give high probability and certitudes of having VAP.

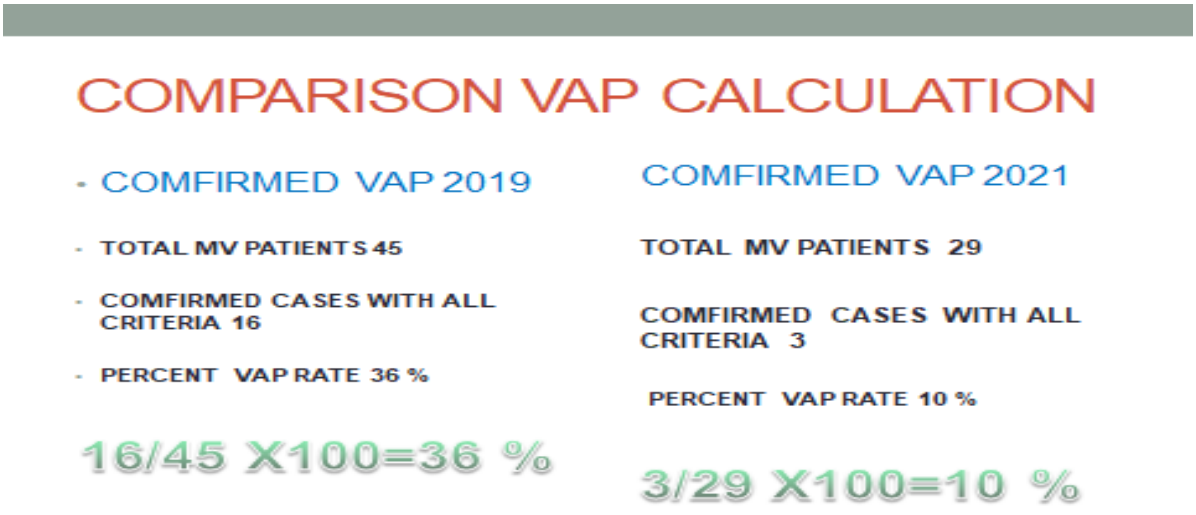

Figure 7: VAP 2019 and 2021 calculation

4.2.6 VAP all combined variable on Mechanical Ventilated patients

Table 23: VAP all combined variable on Mechanical Ventilated patients

			WBC			
		Row Labels	**NO**	**YES**	**Grand Total**	%
		Yr 2019	**10**	**35**	**45**	
Xray-		**NO**	**4**	**7**	**11**	
	Fever	NO	1		1	
		NA	1		1	
	Fever	YES	3	7	10	
	lab	NA	3	4	7	
		NO		1	1	
	Lab	YES		2	2	
Xray+		**YES**	**6**	**28**	**34**	
	Fever-	NO	1	2	3	
		NA		1	1	
		NO	1	1	2	
	Fever+	YES	5	26	31	
		NA	3	4	7	
		NO	2	6	8	
	Lab+	YES		16	16	36%
		Yr 2021	**13**	**16**	**29**	
Xray -		**NO**	**7**	**10**	**17**	
	Fever	NO	4	4	8	
		NA	2	1	3	
		NO	2	1	3	
		YES		2	2	
	Lab	YES	3	6	9	
		NA		1	1	
		NO	3	2	5	
		YES		3	3	
Xray+		**YES**	**6**	**6**	**12**	
		NO	5	1	6	
		NA	2		2	
		NO	3	1	4	
	Fever+	YES	1	5	6	
		NA		1	1	
		NO	1	1	2	
	Lab+	YES		3	3	10%
		Grand Total	**23**	**51**	**74**	

The above table 24 demonstrates that in 2019 only 16 out of 45 patients have all combined VAP criteria while in 2021 only 3 patients out of 29 patients have VAP. This shows the reduction of VAP incidence arte after intervention.

4.2.7 Is this study improved or not?

The following graphs show the improvement level of three indicators 2019-2021.

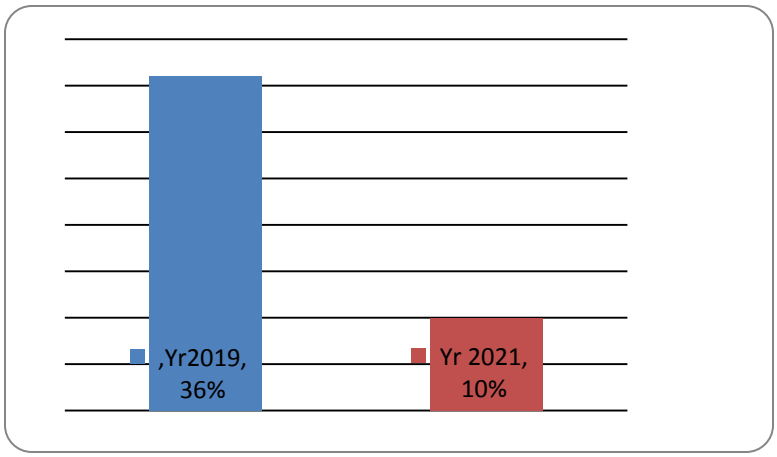

Figure 8: VAP incidence rate in comparison

Source: Primary data ICU /VAP rate 2019 and 2021

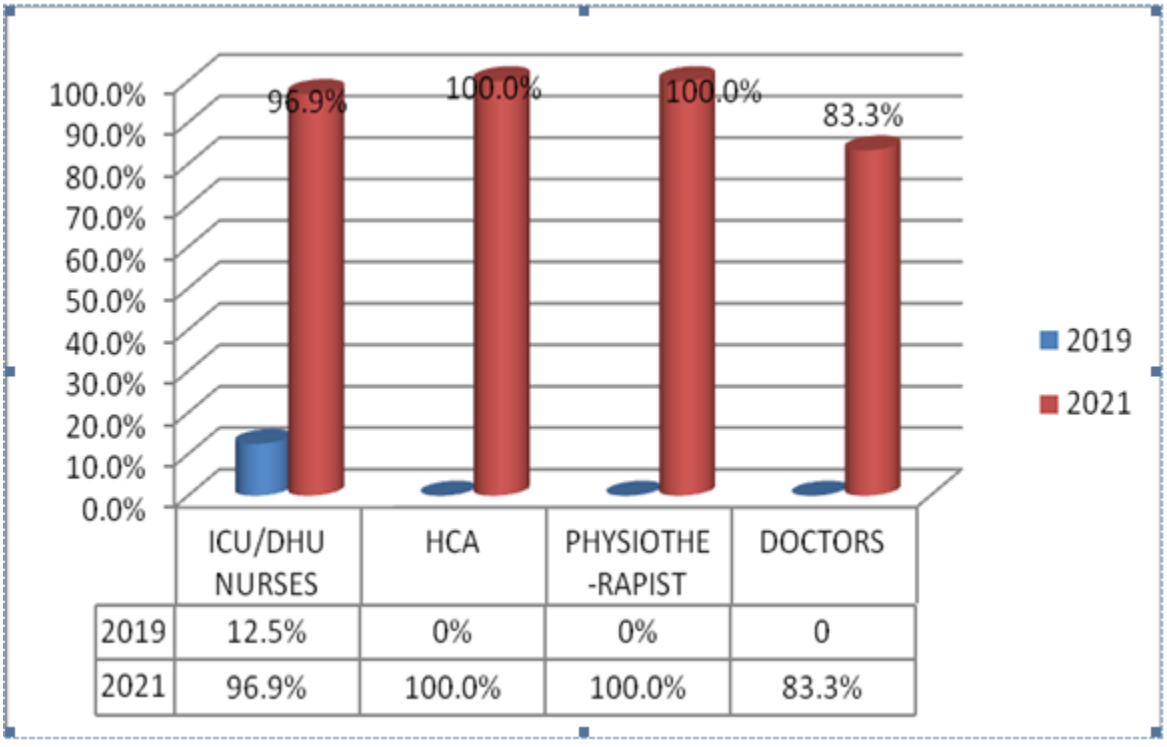

Figure 9: Staff training on EBG on VAP preventive measure in Comparison

Source: Primary data ICU clinical staff training on EBG 2019 and 2021

Table 24: Observational data on EBG of VAP preventive measures 2020-2021.

	Criteria	2020				2021			
1	Head of bed elevation 30-45/ semi seated position		PC		51.1	C			90.0
2	Oral care with antiseptic agent available			NC	30.6	C			91.1
3	Stress ulcer prophylaxis	C			82.1	C			99.5
4	Deep Venous thrombosis prophylaxis (DVT)	C			81.5	C			99.7
5	Daily assessment of sedation and spontaneous breathing test (SBT)			NC	36.1	C			85.4
6	Alcohol-based hand rubbing and washing as per policy	C			83.0	C			90.2
7	Aseptic technique when suctioning via tracheostomy and ETT		PC		54.4	C			86.4
8	Single use of suction catheters/tubes	C			81.7	C			99.2
9	Clean the suction tubing with sterile water	C			82.2	C			98.8
10	Change of tracheostomy stoma done aseptically	C			81.0	C			98.6
11	Appropriate use of PPE	C			80.8	C			99.2
12	Early extubation whenever possible			NC	27.1	C			85.4
13	Change of suctioning tubing /bottles between use per shift	C			80.9	C			99.5
14	Change of Ventilator tubing every 7 days			NC	34.6		PC		78.1
15	Use of Oral intubation preferably as opposed to nasal	C			81.6	C			99.8
16	Use of appropriate inflated cuffed ETT or Tracheostomy tube (>20 cmH2O) controlled by manometer			NC	19.2	C			85.2
17	Appropriate cleaning and disinfection/sterilization of reusable suctioning equipment	C			80.4	C			90.1
18	Sterilize resuscitation bags, clean nebulizer kits between use and keep dry			NC	26.5		PC		77.0
19	Keep equipment dry and clean to prevent microbial contamination (including clean intubation).		PC		50.0	C			81.2
20	Use of tubes (ETT, Tracheostomy) with Subglottic aspiration extra lumen			NC	0.0			NC	0.0
21	Use of closed circuit aspiration system			NC	26.4		PC		76.4
	AVERAGE IN %	**55.8 %**				**86.2%**			

Source: Primary data ICU/KFH compliance level of EBG 2020 and 2021

The above table 25 shows also very good improvement in EBG compliance overall from 55.8 % to 86.2%, excellent change. But due to cost constraints some time ICU doesn't has enough ventilator circuit to be changed every week. It doesn't has also tubes (ETT, Tracheostomy) with Subglottic aspiration extra lumen. The Use of closed circuit aspiration system (inline suction catheters) not also available all the time. Sterilization of resuscitation bag still has concern.

Table 25: Summarized table on EBG and VAP with Statistical testing.

	2019	2021		
Evidence based Guideline (criteria)	**Compliance level(Pre)-%**	**Compliance Level (Post)-%**	**Std Deviation**	**P-value**
Head of bed elevation 30-45/ semi seated position	51.1	90.0	16.61	0.000
Oral care with antiseptic agent available	30.6	91.1	13.677	0.000
Stress ulcer prophylaxis	82.1	99.5	5.161	0.000
Deep Venous thrombosis prophylaxis (DVT)	81.5	99.7	5.421	0.000
Daily assessment of sedation and spontaneous breathing test (SBT)	36.1	85.4	18.693	0.000
Alcohol-based hand rubbing and washing as per policy	83.0	90.2	7.91	0.000
Aseptic technique when suctioning via tracheostomy and ETT	54.4	86.4	17.117	0.000
Single use of suction catheters/tubes	81.7	99.2	5.003	0.000
Clean the suction tubing with sterile water	82.2	98.8	6.38	0.000
Change of tracheostomy stoma done aseptically	81.0	98.6	4.924	0.000
Appropriate use of PPE	80.8	99.2	5.261	0.000
Early extubation whenever possible	27.1	85.4	13.051	0.000
Change of suctioning tubing /bottles between use per shift	80.9	99.5	4.39	0.000
Change of Ventilator tubing every 7 days	34.6	78.1	12.316	0.000
Use of Oral intubation preferably as opposed to nasal	81.6	99.8	4.452	0.000
Use of appropriate inflated cuffed ETT or Tracheostomy tube (>20 cmH2O) controlled by manometer	19.2	85.2	9.336	0.000
Appropriate cleaning and disinfection/sterilization of reusable suctioning equipment	80.4	90.1	8.893	0.000
Sterilize resuscitation bags, clean nebulizer kits between use and keep dry	26.5	77.0	10.96	0.000
Keep equipment dry and clean to prevent microbial contamination (including clean intubation).	50.0	81.2	13.107	0.000
Use of tubes (ETT, Tracheostomy) with Subglottic aspiration extra lumen	0.0	0.0	NA	NA
Use of closed circuit aspiration system	26.4	76.4	12.048	0.000
AVERAGE	**55.8**	**86.2**	**15.232**	**0.000**
VAP	**35.6**	**10.0**	**12.783**	**0.000**

4.2.8 Statistical testing and Hypothesis testing.

Alternative Hypothesis: ICU clinical staff training reduces VAP incidence rate.

Null hypothesis: ICU clinical staff training will not reduce VAP incidence rate.

Reference made to the previous table 26 (Summarized table on EBG and VAP) and annex 6 Paired Samples Statistics and Paired Samples Test**.**

Ho Null hypothesis: VAP incidence rate pre-intervention =VAP Post training: No difference between result of training EBG or there is no impact of training.

H1 Alternative Hypothesis: VAP incidence rate Pre-training ≠ VAP incidence rate post training. There is an impact of EBG training on VAP incidence rate.

The level of significant of Alpha σ = 0.05 (confidence of 95%)

If P value > 0.05 no difference

If P Value < 0.05 there is difference

According to sample to Paired sample statistics test the overall average of p-value is 0.000 which is less than alpha 0.05. This study shows that there is a huge impact on confidence of 95% that, there is strong relationship between EBG training with its level of compliance and VAP incidence rate in ICU KFH.

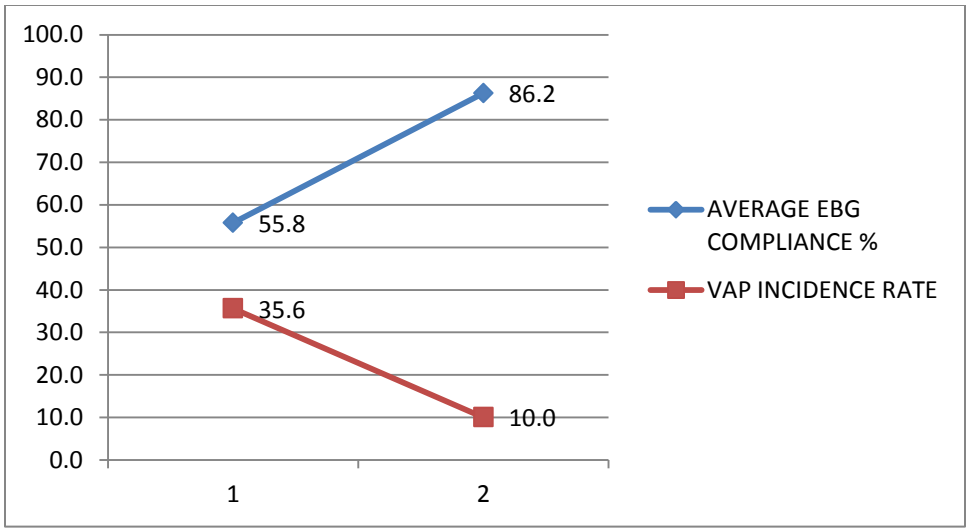

Figure 10: Impact of EBG training on VAP incidence rate

CHAPTER FIVE: DISCUSSION

A study by Aloush in Brazil 2017 found that declining caregiver-to-patient ratios, inadequate caregivers training, and constantly changing caregivers especially nurses, are source of increasing infection rates. (25). It is essential to decrease the workload of nurses , to enhance their compliance and strengthen the effectiveness of education(26).

In this pre post interventional study also there is big effect on VAP incidence rate reduction due clinical staff education and training on EBG of VAP preventive measure in ICU/KFH.

5.1 Study main achievements

The overall project implementation was very successful as all indicators and objective was achieved. The main objective was the VAP reduction in 3 months of intervention. The objective was to reduce VAP from 36% to 13% now this quality improvement went even beyond the target. The target was the reduction of VAP rate at 50% but the reduction was at 65%.

Table 26: Achievements of indicators

	indicator	**Outcome target**	**Results**	**Observation**
1	Increase knowledge of nursing staff on VAP prevention by training.	Training at 100%	96.9%	Almost achieved
2	Increase compliance rate of EBGs of VAP preventive measures	compliance rate > 80%	86.2%	Achieved
3	**VAP rate reduction of 50%**	From 36% to 13 %	10%	Achieved more than expected

Source: Primary data Study achievements

5.2 Other success of study

1. All reusable resuscitation bags, mask, oral cannula cleaned, decontaminated sterilized by Cidex then packed.
2. Oral care with available antiseptic with introduction of new suction brushing.
3. Early extubation/ extubation policy updated and implemented (No more fixed time).
4. Ventilator Exhalation Valves sterilized before use.

5. Infection surveillance policy new implemented (Septic screening of ICU patients in 24 Hours of admission).
6. Use of appropriate inflated cuffed ETT or Tracheostomy tube (>20 cmH2O) controlled by manometer (pressure manometer available in ICU).
7. Daily sedation assessment and SBT implemented (Every morning).
8. Reduction of invasive ventilation (increment of Noninvasive CPAP for adult and Nasal CPAP for Pediatric cases).

5.3. Challenges

Time constraints: This pre post intervention study require too much time in identifying the problem, in finding root cause analysis, interventions, in writing report on every stage of hospital attachment. Trying to convince the team of clinical staff who already think they are doing well, to change and participate actively in activities required different meeting and long discussions.

Budget constraints: Busy clinical staff may need incentives if they have to attend trainings, participate in observational and quality improvement activities. This reduces staff motivation and lack of staff engagement in some planned activities. The budget also has limited to hire a qualified statistician for enough periods. No financial support received from hospital or other institutions.

Getting all data and system monitoring in right time: Data collection and feedback are indispensable for this pre post intervention study. Data help also in demonstrating the scale of quality improvement and show what is going on in response to best intervention. But lack of experience and expertise in data collection, sometime data set poorly designed, they were a struggle to get all data and figures needed in right time. There were also complexity of data from patient's files, NAPIER/JEEVA laboratory system and CXR from MEDSYNAPSE PACS imaging system all of these needed time, access and enough staff.

5.3.1. How to overcome the challenges?

- Use of my resting time, being proactive and choose less costly intervention.
- Collaborative approach, effective communication and team work activities.
- Discipline, hard work and use of available skills and resources.

5.3.2. Lesson learned during the project

This project tough me how to identify health problem and how to solve scientifically any health issue. It was a good opportunity to apply into practice all lessons learned at school (statistics, ethic, problem solving, management, research, HRM and hospital operations etc.).

The results of this pre-post intervention study concern the reduction of VAP rate, on evidence based guideline, and increase knowledge of ICU clinical staff in VAP preventive measures which lead to quality of care administered to the critically ill patients.

5.4. What needs to improve?

According to the successfulness of this study there is a need for regular training of ICU staff on EBG especially for new staff in orientation program. There is also a need to buy enough ventilator circuits and ETT with subglottic extra lumen for chronic ICU patients. With the increasing advances in health sciences, including nursing sciences, there is an expanding need to constantly update knowledge, information, to develop new skills in order to provide patients with the excellent health care.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

Nurse's lack of training on EBGs for prevention of VAP was the main cause of high VAP rate in ICU/KFH and EBG's helps to implement for VAP prevention, it is important to be aware of such measures. Without this training knowledge, nursing practice, skills, and patient care are not of excellent standards. The clinical staff training has elevated nurse's knowledge, compliance rate of EBG's and finally VAP rate reduction. It is documented that VAP rate reduction reduces health care cost, reduces ICU mortality rate and the overall improve patient quality of care. It remains essential to promote continuing education and in services training on current evidence-based guidelines to escalate awareness of VAP.

6.2 Recommendations

For practice: it is by great importance in future to have training on EBG's especially during rotation in ICU. Any orientation or admission of new staff in ICU should incorporate also VAP preventive measures in routine and daily practices. The unit in future should have continuous training of policies and guidelines governing the unit for perfect patient care delivery. The protocols and guidelines should be revised regularly and update them. New evidence of best practices is constantly growing and clinical staff should be educated on the updated guidelines.

For quality improvement and Policies: it is by great importance of having the policies in place, but it will remain crucial to promote continuous education and in services trainings of policies and guideline with monitoring and evaluation of how those guideline are put in practices.

For further research and education: This pre post intervention study has calculated the VAP incidence rate. For the future study it should calculate also the VAP incidence density on 1000 ventilator days. It should also differentiate the ventilator Associated Pneumonia to Ventilator Associated Event in ICU/KFH.

This study should be extended to different Rwandan ICU's to include other hospitals with a large population and sample. It will be also by great importance to extend time of study.

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ANNEX

Annex 1. Evidence Based Guideline on VAP preventive measures

Considering their views most of them have mentioned measures of standards on VAP prevention and the following questionnaire was developed on the use of VAP bundle and evidence based – practices and guidelines for prevention of ventilator associated pneumonia as was elaborated by CDC adopted by KFH. It was used as an audit tool, check list and finally as an education and training tool.

We will use the scale from 1 to 5 to verify the implementation levels.

	Criteria	**C=3**	**PC=2**	**NC=1**
1	Head of bed elevation 30-45/ semi seated position			
2	Oral care with antiseptic agent available			
3	Stress ulcer prophylaxis			
4	Deep Venous thrombosis prophylaxis			
5	Daily sedation assessment and spontaneous breathing trials			
6	Alcohol-based hand rubbing and washing as per policy			
7	Aseptic technique when suctioning via tracheostomy and ETT			
8	Single use of suction catheters/tubes			
9	Clean the suction tubing with sterile water			
10	Change of tracheostomy stoma done aseptically			
11	Appropriate use of PPE			
12	Early extubation whenever possible			
13	Change of suctioning tubing /bottles between use per shift			
14	Change of Ventilator tubing every 7 days			
15	Use of Oral intubation preferably as opposed to nasal			
16	Use of appropriate inflated cuffed ETT or Tracheostomy tube (>20 cmH2O) controlled by manometer			
17	Appropriate cleaning and disinfection/sterilization of reusable suctioning equipment			
18	Sterilize resuscitation bags, clean nebulizer kits between use and keep dry			
19	Keep equipment dry and clean to prevent microbial contamination			
20	Use of tubes (ETT,Tracheostomy) with Subglottic aspiration			
21	Use of closed circuit aspiration system			

C= Compliant >80%; PC= Partial Compliant 50-79%; NC=Non-Compliant 0-49%

ANNEX 2. Questionnaire of ICU staff knowledge on VAP preventive interventions.

Evaluation questionnaire concerning intensive care nurses' knowledge of interventions for prevention of ventilator-associated pneumonia (VAP).

This questionnaire is anonymous. Please do not write your name.

Please indicate the following: Sex: Male ☐ Female ☐

Age: **1**= (21-30); **2**=(31-40) ; **3**= (41-50) ; **4** = >50 years

Years working in ICU: □ <1year □ 1-5 years □ 6-10 years □ >10 years

Which is the highest Degree or Diploma in Nursing?

Associate Nurse A2 □, RN A1□, Degree (A0) in Nursing □, Maters Degree □

Did you have training on EBG for VAP prevention in past 1 year (2021)?

Yes □ No □ →if No Skip

Some of the internationally proposed strategies for preventing VAP are listed below. Please mark which interventions are recommended in the evidence-based guidelines for prevention of VAP.

1. Oral vs nasal route for endotracheal intubation

a) Oral intubation is recommended

b) Nasal intubation is recommended

c) Both routes of intubation can be recommended

d) I do not know

2. Frequency of ventilator circuit changes

a) It is recommended to change circuits every 48 hours (or when clinically indicated)

b) It is recommended to change circuits every week (or when clinically indicated)

c) It is recommended to change circuits for every new patient (or when clinically indicated)

d) I do not know

3. Type of humidifier

a) Heated humidifiers are recommended

b) Heat and moisture exchangers are recommended

c) Both types of humidifiers can be recommended

d) I do not know

4. Frequency of humidifiers changes

a) It is recommended to change humidifiers every 48 hours (or when clinically indicated)

b) It is recommended to change humidifiers every 72 hours (or when clinically indicated)

c) It is recommended to change humidifiers every week (or when clinically indicated)

d) I do not know

5. Open vs closed suction systems

a) Open suction systems are recommended

b) Closed suctions systems are recommended

c) Both systems can be recommended

d) I do not know

6. Frequency of change in suction systems

a) Daily changes are recommended (or when clinically indicated)

b) Weekly changes are recommended (or when clinically indicated)

c) It is recommended to change systems for every new patient (or when clinically indicated)

d) I do not know

7. Endotracheal tubes with extra lumen for drainage of subglottic secretions

a) These endotracheal tubes reduce the risk for VAP

b) These endotracheal tubes increase the risk for VAP

c) These endotracheal tubes do not influence the risk for VAP

d) I do not know

8. Kinetic vs standard beds

a) Kinetic beds increase the risk for VAP

b) Kinetic beds reduce the risk for VAP

c) The use of kinetic beds does not influence the risk for VAP

d) I do not know

9. Patient positioning

a) Supine positioning is recommended

b) Semirecumbent positioning is recommended

c) The position of the patient does not influence the risk for VAP

d) I do not know

10. Daily sedation assessment and spontaneous breathing trials (SBT)

a) Daily sedation assessment and SBT not recommended in VAP prevention

b) Daily sedation assessment and SBT recommended in VAP prevention

c) Daily sedation assessment and SBT not influence the risk for VAP

d) I do not know

Thank you for your contribution.

Annex 3: Ethical clearances from UR and KFH, Kigali

KING FAISAL HOSPITAL KIGALI

KING FAISAL HOSPITAL, KIGALI

Patient Centered Care

20th October, 2020

NGIRIMANA JEAN BAPTISTE DE LA SALLE

We acknowledge receipt of your study protocol: **"REDUCING VENTILATOR-ASSOCIATED PNEUMONIA IN ICU, KFH KIGALI 2020-2021."**

After a thorough review, the reviewers of KFH Ethics Research Committee consider this study relevant. The investigator is allowed to start data collection after addressing the reviewers' comments.

N.B. The investigator is ***requested to submit one hard copy of his final research results*** in the office of the Directorate of Education, Training and Research at King Faisal Hospital, Kigali

Best Regards

KING FAISAL HOSPITAL • KIGALI

Dr. Dushimiyimana Jean Marie Vianney
Consultant ENT surgeon
Chair, Ethics Research Committee
King Faisal Hospital, Kigali.

CC:
1. Chief Executive Officer_ KFH-Kigali
2. Members of the KFH Ethics Research Committee

UNIVERSITY of RWANDA

COLLEGE OF MEDICINE AND HEALTH SCIENCES

DIRECTORATE OF RESEARCH & INNOVATION

CMHS INSTITUTIONAL REVIEW BOARD (IRB)

Kigali, 22/06/2020
Ref: CMHS/IRB/200/2020

NGIRIMANA Jean Baptiste De La Salle

Masters in Hospital and Healthcare Administration,
School of Health Sciences, CMHS, UR

Dear NGIRIMANA Jean Baptiste De La Salle,

RE: ETHICAL CLEARANCE

Reference is made to your application for ethical clearance for the study entitled ***"Reducing Ventilator-Associated Pneumonia In ICU, KFH Kigali 2020-2021."***

Having reviewed your application and been satisfied with your protocol, your study is hereby granted ethical clearance. The ethical clearance is valid for one year starting from the date it is issued and shall be renewed on request. You will be required to submit the progress report and any major changes made in the proposal during the implementation stage. In addition, at the end, the IRB shall need to be given the final report of your study.

We wish you success in this important study.

Professor GAHUTU Jean Bosco
Chairperson Institutional Review Board,
College of Medicine and Health Sciences, UR

Cc:

- Principal College of Medicine and Health Sciences, UR
- University Director of Research and Postgraduate studies, UR

Annex 4: VAP DATA COLLECTION FORM 2021 & 2019

No	IP Number	Patient Name	Gender	Age	Admission date	No of DAYS	INTUBATED Y/N	dead 0/alive 1	New/progressive infiltrated	Fever	WBC: Lecocytosis/ Leucopenia	Purulent secretion	Microbiology/positive trac.Asp	District	Month	Year	Dgc
3			M	62	10/4/2021	6	y	0	YES	YES	YES	NA	NA				
4			M	73	10/3/2021	8	y	0	NO	NO	YES	NA	NA				
5			F	9	10/15/2021	19	Y	1	YES	YES	YES	YES	YES				
6			F	44	10/15/2021	4	Y	0	NO	YES	YES	NO	NA				
7			F	81	10/20/2021	3	Y	0	YES	NO	YES	NO	NO				
8			F	29	11/13/2021	8	Y	0	NO	YES	NO	NA	NO				
9			M	28	12/21/2021	4	y	1	NO	YES	YES	NA	NO				
10			M	0.83	10/23/2021	3	Y	0	NO	YES	NO	NA	NO				
11			M	46	10/25/2021	3	Y	1	YES	NO	NO	NA	NA				
12			F	37	10/27/2021	3	Y	1	NO	NO	NO	NO	NA				
13			M	85	10/28/2019	14	Y	0	NO	yes	YES	YES	YES				
14			F	32	10/29/2019	64	y	1	YES	YES	YES	yes	YES				
15			F	60	10/1/2019	92	Y	0	yes	YES	YES	YES	YES				
16			F	42	11/1/2019	6	Y	1	NO	NO	YES	NA	NO				

Legend: Yes= Available or positive, No= Not available or Negative, NA= Not available.

Annex 5: IMPLEMENTATION PLAN (GANTT'S CHART)

	Activities/Tasks	Responsible	TIMELINE & SEQUENCES 2021-2022				
NO	Activities/Tasks	Persons	01-06/2021	06-10/2021	10-12/2021	01-02/2022	2-3-4/2022
1	Introduction of the project	R					
2	Training ICU/HDU Nurses Phase I	R					
3	Training of HCA	R,SL					
4	Demonstration of oral/Mouth care	R					
5	Demonstration of equipment Decontamination	R,SL					
6	Training ICU/HDU Nurses Phase 2	R					
7	Training of Physiotherapist	R& DS					
8	Training on specific criterion of VAP bundles	DS					
9	Training of ICU medical DRs including students	R&DS					
10	Communication of project progress to IPC committee	R					
11	Communication of HA to team including UR supervisors	R					
12	Monitor project implementation	R					
13	Data collection of guideline compliance	R,DS					
14	Presentation of project to the research and quality improvement team	R					
15	Admission of simplified VAP bundles in Patient file	DS					
16	End line post intervention data collection, analysis and report writing	R,Statistician					
17	Final dissertation / Capstone	R					
18	Peer review and publication process	R					

Legend: R=Researcher; DS= Designed Staff ; SL=Shift Leader

ANNEX 6: PLAGIALISM ,SIMILARITY AND ORIGINALITY REPORT

Date :07/11/2022

Note

The Study Entitled "REDUCING VENTILATOR- ASSOCIATED PNEUMONIA IN INTENSIVE CARE UNIT AT KING FAISAL HOSPITAL, KIGALI.2020-2022"is approved by the Directorate of Research and Innovation for submission in UR_CMHS Library . The plagiarism report is 12% with the following parametters :

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Sincerely

Emile Nisingizwe

Research and Innovation Officer,CMHS

REDUCING VENTILATOR- ASSOCIATED PNEUMONIA IN INTENSIVE CARE UNIT AT KING FAISAL HOSPITAL, KIGALI.2020-2022

ORIGINALITY REPORT

12%	9%	6%	5%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

Annex 7: Paired Samples Statistics and Paired Samples Test.

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	PRE_HBE	51.06	32	13.188	2.331
	POST_HBE	90.03	32	7.227	1.278
Pair 2	PRE_Oral	30.41	32	9.794	1.731
	POST_Oral	91.06	32	6.715	1.187
Pair 3	PRE_SUP	82.13	32	4.654	.823
	POST_SUP	99.53	32	1.481	.262
Pair 4	PRE_DVT	81.50	32	4.899	.866
	POST_DVT	99.69	32	1.230	.217
Pair 5	PRE_SBT	36.09	32	19.081	3.373
	POST_SBT	85.38	32	6.424	1.136
Pair 6	PRE_Alcohol	83.00	32	5.310	.939
	POST_Alcohol	90.22	32	5.988	1.059
Pair 7	PRE_Aseptic	54.38	32	15.911	2.813
	POST_Aseptic	86.41	32	6.505	1.150
Pair 8	PRE_SU	81.66	32	4.763	.842
	POST_SU	99.22	32	2.239	.396
Pair 9	PRE_Clean	82.19	32	4.974	.879
	POST_clean	98.75	32	2.540	.449
Pair 10	PRE_change	80.97	32	4.604	.814
	POST_change	98.59	32	2.906	.514
Pair 11	pre_PPE	80.75	32	4.718	.834
	post_PPE	99.22	32	2.239	.396
Pair 12	PRE_Early	27.13	32	8.780	1.552
	POST_Early	85.38	32	6.298	1.113
Pair 13	PRE_Suctionchange	80.91	32	4.603	.814
	POST_suctionchange	99.53	32	1.481	.262
Pair 14	PRE_VT	34.63	32	9.537	1.686
	POST_VT	78.09	32	7.109	1.257
Pair 15	PRE_UOT	81.56	32	4.235	.749
	POST_UOT	99.84	32	.884	.156
Pair 16	PRE_CUFT	19.22	32	7.737	1.368
	POST_CUFT	85.22	32	6.241	1.103
Pair 17	PRE_Apr_clean	80.44	32	5.086	.899
	POST_Apr_clean	90.06	32	5.924	1.047
Pair 18	PRE_sterilize	26.50	32	8.254	1.459
	POST_sterilize	77.00	32	6.011	1.063
Pair 19	PRE_dry	50.00	32	11.500	2.033
	POST_dry	81.22	32	4.346	.768
Pair 20	PRE_Subglottic	.00[a]	32	.000	.000
	POST_Subglottic	.00[a]	32	.000	.000
Pair 21	PRE_inline	26.41	32	8.056	1.424
	POST_inline	76.41	32	6.505	1.150

a. The correlation and t cannot be computed because the standard error of the difference is 0.

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	PRE_HBE - POST_HBE	-38.969	16.610	2.936	-44.957	-32.980	-13.271	31	.000
Pair 2	PRE_Oral - POST_Oral	-60.656	13.677	2.418	-65.587	-55.725	-25.087	31	.000
Pair 3	PRE_SUP - POST_SUP	-17.406	5.161	.912	-19.267	-15.546	-19.079	31	.000
Pair 4	PRE_DVT - POST_DVT	-18.188	5.421	.958	-20.142	-16.233	-18.980	31	.000
Pair 5	PRE_SBT - POST_SBT	-49.281	18.693	3.305	-56.021	-42.542	-14.913	31	.000
Pair 6	PRE_Alcohol - POST_Alcohol	-7.219	7.910	1.398	-10.071	-4.367	-5.163	31	.000
Pair 7	PRE_Aseptic - POST_Aseptic	-32.031	17.117	3.026	-38.203	-25.860	-10.586	31	.000
Pair 8	PRE_SU - POST_SU	-17.563	5.003	.884	-19.366	-15.759	-19.858	31	.000
Pair 9	PRE_Clean - POST_clean	-16.563	6.380	1.128	-18.863	-14.262	-14.685	31	.000
Pair 10	PRE_change - POST_change	-17.625	4.924	.870	-19.400	-15.850	-20.250	31	.000
Pair 11	pre_PPE - post_PPE	-18.469	5.261	.930	-20.365	-16.572	-19.859	31	.000
Pair 12	PRE_Early - POST_Early	-58.250	13.051	2.307	-62.955	-53.545	-25.248	31	.000
Pair 13	PRE_Suctionchange - POST_suctionchange	-18.625	4.390	.776	-20.208	-17.042	-23.998	31	.000
Pair 14	PRE_VT - POST_VT	-43.469	12.316	2.177	-47.909	-39.028	-19.966	31	.000
Pair 15	PRE_UOT - POST_UOT	-18.281	4.452	.787	-19.886	-16.676	-23.228	31	.000
Pair 16	PRE_CUFT - POST_CUFT	-66.000	9.336	1.650	-69.366	-62.634	-39.991	31	.000
Pair 17	PRE_Apr_clean - POST_Apr_clean	-9.625	8.893	1.572	-12.831	-6.419	-6.123	31	.000
Pair 18	PRE_sterilize - POST_sterilize	-50.500	10.960	1.938	-54.452	-46.548	-26.064	31	.000
Pair 19	PRE_dry - POST_dry	-31.219	13.107	2.317	-35.944	-26.493	-13.474	31	.000
Pair 21	PRE_inline - POST_inline	-50.000	12.048	2.130	-54.344	-45.656	-23.476	31	.000