MULTI MODALITY INTERVENTION INFECTION CONTROL (MIMIC) ON KNOWLEDGE AND PRACTICE AMONG CRITICAL CARE NURSING STAFF IN HOSPITAL USM

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by

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LIST OF SYMBOLS

e.g.	For example
et al.	And others
>	More than
<	Less than
≥	Equal or more than
≤	Equal or less than
N	Sample size
N	Population size
&	And
%	Percentage
=	Equal to
P	Prevalence
E	Degree of precision
Z	Critical value of the normal distribution
ηp2	Partial eta squared
(d)	Threshold
°C	Degree Celsius
H_1	Alternative hypothesis

LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
APIC	Association for Professionals in Infection Control and Epidemiology
BBE	Bare Below the Elbow
BSI	Blood Stream Infection
CAUTI	Catheter-Associated Urinary Tract Infection
CCTV	Closed Camera Television
CDC	Centers for Disease Control and Prevention
CFU	Colony-Forming Unit
CI	Confidence Interval
CLABSI	Central Line-Associated Bloodstream Infection
cmH2O	centimetres of water
CNE	Continuous Nursing Education
CO	Change Objective
CPD	Continuing Professional Development
CRA	Carbapenem Resistant Acinetobacter
CRA	Carbapenem Resistant Acinetobacter
CRE	Carbapenem-Resistant Enterobacteriaceae
CVC	Central Venous Catheter
ESBL	Extended-Spectrum β-Lactamase
ETT	Endotracheal Tube
FDM	Fuzzy Delphi Method
FiO2	Fraction of Inspired Oxygen
HAI	Healthcare-Associated Infection
HCW	Healthcare Worker

HH	Hand Hygiene
HIACC	Hospital Infection and Antibiotic Control Committee
HUSM	Hospital Universiti Sains Malaysia
ICAT	Infection Control Assessment Tool
ICC	Infection Control Committee
ICD	Infection Control Doctor
ICEP	Infection Control Education Program
ICLN	Infection Control Link Nurse
ICMS	Infection Control Monitoring System
ICMS-MF	Infection Control Monitoring System-Monitoring Forms
ICMS-ST	Infection Control Monitoring System-Statistical Tool
ICN	Infection Control Nurse
ICSE	Infection Control Supportive Environment
ICT	Infection Control Team
ICU	Intensive Care Unit
IM protocol	Intervention Mapping Protocol
IPC	Infection Prevention and Control
IUC	Indwelling Urinary Catheter
IV	Intravenous
IWP	Infection Window Period
KP	Klebsiella Pneumoniae
LOS	Length of Stay
M	Mean
MCO	Movement Control Order
MD	Mean Difference
MDR-AB	Multidrug Resistant Acinetobacter Baumannii
MDROs	Multidrug Resistance Organisms

MIMIC	Multi-Modality Intervention Infection Control
MMOH	Malaysian Ministry of Health
MRSA	Methicillin-Resistant Staphylococcus Aureus
MV	Mechanical Ventilator
ONCG	Oral Nursing Care Guideline
OS	Organizational Support
PE	Physical Environment
PEEP	Positive End-Expiratory Pressure
PICC	Peripherally Inserted Central Catheter
PO	Performance Objective
PPE	Personal Protective Equipment
PsA	Pseudomonas Aeruginosa
RRR	Retrospective Record Review
RCT	Randomized Controlled Trial
RP	Risk Perception
SCT	Social Cognitive Theory
S-CVI	Scale Level Content Validity Index.
SD	Standard Deviation
SE	Self-Efficacy
SPSS	Statistical Package for the Social Sciences
SSI	Surgical Site Infection
TFN	Triangular Fuzzy Numbers
UC	Urinary Catheter
USM	Universiti Sains Malaysia
UTI	Urinary Tract Infection
VAP	Ventilator-Associated Pneumonia
VRE	Vancomycin-Resistant Enterococci

WBC	White Blood Cells
WHO	World Health Organization

LIST OF APPENDICES

INTERVENSI KAWALAN INFEKSI PELBAGAI MODALITI (MIMIC) KE ATAS PENGETAHUAN DAN AMALAN DALAM KALANGAN JURURAWAT JAGAAN KRITIKAL DI HOSPITAL USM

ABSTRAK

Jangkitan dapatan hospital (HAI) adalah masalah kesihatan yang sangat penting dengan kesan yang besar terhadap sektor penjagaan kesihatan di seluruh dunia. Kajian-kajian yang menumpukan kepada pelaksanaan modul multi-modaliti yang diwujudkan kepada jururawat penjagaan kritikal adalah sangat terhad. Tujuan kajian ini adalah untuk menilai kesan modul multi-modaliti terhadap tahap pengetahuan dan amalan jururawat penjagaan kritikal dewasa mengenai pencegahan dan kawalan HAI di Hospital Universiti Sains Malaysia. Kajian ini dijalankan dalam tiga fasa. Fasa pertama melibatkan tinjauan carta retrospektif untuk menilai prevalens HAI. Di samping itu, kajian keratan rentas deskriptif dilakukan untuk menilai sistem pengendalian jangkitan yang diaplikasikan. Fasa kedua pula menumpukan kepada pengembangan modul kawalan jangkitan Multimodaliti pelbagai intervensi menggunakan protokol Intervensi Pemetaan (IM) dan Teori Kognitif Sosial (SCT), serta mengesahkan modul yang dikembangkan menggunakan Kaedah Fuzzy Delphi (FDM). Fasa ketiga terdiri daripada kajian kuasi-eksperimen pretest-posttest satu kumpulan untuk menilai kesan modul yang dikembangkan. Prevalens HAI selama satu tahun adalah 5.84%. Selain itu, penilaian sistem kawalan jangkitan telah mengenal pasti bidang yang perlu dilakukan penambahbaikkan. Modul yang dibangunkan merangkumi tiga intervensi: program pendidikan pengendalian jangkitan, sistem pemantauan pengendalian jangkitan, dan sokongan persekitaran kawalan jangkitan, telah disahkan oleh tujuh panel pakar. Tahap pengetahuan dan

amalan jururawat penjagaan kritikal dewasa telah dinilai sebanyak dua kali: sejurus sebelum dan tiga bulan selepas intervensi (n = 121); penilaian pra-intervensi menunjukkan bahawa 96.7% daripada responden mempunyai tahap amalan pengetahuan yang sederhana, dengan skor purata 18.68 daripada 30 (SD = 2.255) dan 95% CI [18.27, 19.08]. Dan 79.3% daripada responden mempunyai tahap praktik yang sederhana, dengan skor purata 8.79 daripada 15 (SD = 1.449) dan 95% CI [8.53, 9.05]. Penilaian pasca intervensi menunjukkan bahawa 86% responden mempunyai tahap pengetahuan yang baik, dengan skor purata 25.83 daripada 30 (SD = 2.151) dan 95% CI [25.44, 26.21]. Bagi tahap amalan, 62% daripada responden mempunyai tahap yang sederhana, dengan skor purata 10.83 daripada 15 (SD = 1.564) dan 95% CI [10.55, 11.11]. Hasil pengukuran berulang sehala ANOVA menunjukkan satu peningkatan yang signifikan dalam skor pengetahuan, $F (1, 120) = 632,679$, $p < .001$, $\eta p2 = .844$ dan peningkatan yang signifikan dalam skor amalan, $F (1, 120) = 113.089$, $p < .001$, $\eta p2 = .492$. Kesimpulannya, kajian ini telah menyumbang kepada pembentukkan modul intervensi bersepadu yang berkesan dan terbukti dapat meningkatkan pengetahuan dan amalan jururawat penjagaan kritikal dewasa terhadap pencegahan dan kawalan HAI. Ia juga turut membantu untuk memberikan bukti kelebihan protokol IM, SCT, dan FDM dalam membangun dan mengesahkan pencegahan jangkitan dan kawalan intervensi.

MULTI MODALITY INTERVENTION INFECTION CONTROL (MIMIC) ON KNOWLEDGE AND PRACTICE AMONG CRITICAL CARE NURSING STAFF IN HOSPITAL USM

ABSTRACT

Healthcare-Associated Infections (HAIs) are a crucial health problem with significant impacts on healthcare sector worldwide. Studies that focused on the implementation of a multi-modality module tailored to critical care nurses are very limited. The aim of this study was to to determine the Healthcare-Associated Infections prevalence and impact of "Multi-Modality Intervention Infection Control" module on knowledge and practice among critical care nursing staff in Hospital Universiti Sains Malaysia. This study was conducted in three phases. The first phase involved a retrospective record review to assess the prevalence of HAIs. In addition, a descriptive cross-sectional study was conducted to assess the infection control system applied. The second phase focused on developing a multi-modality intervention infection control using the Intervention Mapping (IM) protocol and Social Cognitive Theory (SCT), as well as validating the developed module using the Fuzzy Delphi Method (FDM). The third phase consisted of a one-group pretest-posttest quasi-experimental study to assess the impact of the developed module. The one-year prevalence of HAIs was 5.84%. In addition, the infection control system assessment identified the areas for improvement. The developed module, which includes three interventions: an infection control education program, an infection control monitoring system, and an infection control supporting environment, was validated by a seven-expert panel. The adult critical care nurses' knowledge and practice levels were assessed in two points in time: immediately before and three

months after intervention (n=121); the pre-intervention assessment revealed that 96.7% of the respondents had a fair level of knowledge, with a mean score of 18.68 out of 30 (SD= 2.255) and 95% CI [18.27, 19.08]. And 79.3% of the respondents had a fair level of practice, with a mean score of 8.79 out of 15 (SD= 1.449) and 95% CI [8.53, 9.05]. The post-intervention assessment showed that 86% of the respondents had a good level of knowledge, with a mean score of 25.83 out of 30 (SD= 2.151) and 95% CI [25.44, 26.21]. And for the practice level, 62% of the respondents had a fair level, with a mean score of 10.83 out of 15 (SD= 1.564) and 95% CI [10.55, 11.11]. The one-way repeated measures ANOVA results indicated a significant improvement in knowledge scores, $F(1, 120)= 632.679$, $p < .001$, $\eta p2= .844$. And a significant improvement in practice scores, $F(1, 120)= 113.089$, $p < .001$, $\eta p2= .492$. In conclusion, this study contributed to the development of a comprehensive module of integrated interventions that have proven to improve the adult critical care nurses' knowledge and practice toward HAIs prevention and control. And also helped to provide evidence on the advantage of the IM protocol, SCT, and FDM in developing and validating infection prevention and control interventions.

CHAPTER 1

INTRODUCTION

Healthcare sector encounters several challenges that can impact the quality of the services provided and increase the economic burden of healthcare. These challenges require an ongoing effort to overcome them by developing a set of an evidence-based actions and ensuring their implementation. One of the most significant challenges is healthcare-associated infections (aka nosocomial infections), these infections are a global concern impacting many hospitalized patients' and impeding their treatment plans as well as affecting healthcare workers and unwittingly increasing the risk of diseases transmission across a broad range.

The focus on the HAIs study was traced back to the 1830's, when the term healthcare associated infection was introduced by James Simpson in England, who called the problem "Hospitalism" (Mourud, 2010). Since then, the healthcare sector still face an increasing prevalence of HAIs that affects the quality of patient care. This concern is of interest to decision-makers, health administrators, healthcare workers, and patients.

1.1 Background of the Study

Healthcare-Associated Infections (HAIs) are infections acquired when providing health care in a hospital or in any other healthcare facility that first arise 48 hours or more after admission to hospital (Haque *et al.*, 2018). Furthermore, they include occupational infections among healthcare providers (Khan *et al.*, 2017a). The consequences of HAIs can be seen in increasing morbidity and mortality rates, raising the cost of treatment (Masavkar and Naikwadi, 2016) primarily due to prolonged hospital stay (Manoukian *et al.*, 2018), and most critically developing

causative agents (microorganism) resistant to antibiotics that are used in the treatment of patients (Shoaei *et al.*, 2017). In its fact sheet, WHO reported that the mortality rate and an economic burden are increasing annually due to the high prevalence of HAIs worldwide with 10% of hospitalized patients in developing countries and 7% in developed countries acquiring one of Healthcare-Associated Infections (World Health Organization, 2016b). And more specifically, in Malaysia, the prevalence for HAIs is 13.9% of total hospital admissions (World Health Organization, 2016b).

1.2 Types of Healthcare-Associated Infections (HAIs)

HAIs have four most frequent types (Datta *et al.*, 2014; Ducel *et al.*, 2002; Khan *et al.*, 2017a):

1.2.1 Ventilator-Associated Pneumonia (VAP)

It is a condition of lung infection that occurs 48 hours or longer after tracheal intubation for patients with respiratory difficulties in breathing and receiving mechanical ventilation (Hunter, 2012). VAP is the second most prevalent Healthcare-Associated Infections and the leading cause of high mortality rates among critically ill patients from HAIs (Torres *et al.*, 2017). VAP acquired by 9-27% of mechanically ventilated patients (Khan *et al.*, 2017b).

1.2.2 Central Line-Associated Bloodstream Infection (CLABSI)

It is an infection that the patient acquired within 48 hours of placement a central venous catheter (CVC) and not related to another site infection (Blot *et al.*, 2014). CVCs are central lines placed for blood withdrawing; hemodialysis; infusion of blood products, medications, or fluids; or hemodynamic monitoring. CVCs include Peripheral inserted central catheter (PICC), tunneled catheter, non-tunneled catheter,

and implanted port. CLABSI are deadly infections with the mortality incidence rate of 12-25% (Khan *et al.*, 2017a).

1.2.3 Catheter-Associated Urinary Tract Infections (CAUTI)

It is the most common bacterial infections (40% of HAIs worldwide), associated with the presence of urinary catheter (Tenke *et al.*, 2017). The urinary catheter is inserted via the urethra to the patient's bladder to allow the patient's urine to drain freely from the bladder.

1.2.4 Surgical Site Infections (SSI)

Is an infection occurs after surgery of the organ or surgical incision or space where the surgery took place (Berríos-Torres *et al.*, 2017). SSIs are Healthcare-Associated Infections in 2%–5% of patients undergoing surgery, and the incidence rate could be as high as 20% depending on the surgical procedure (Khan *et al.*, 2017b).

In Southeast Asia, ventilator-associated pneumonia has the highest incidence density (14.7/1000 ventilator day), and for catheter-associated urinary tract infections, and central line-associated bloodstream infections was 8.9/1000 catheter-days, and 4.7/1000 catheter-days, respectively. While the incidence of surgical site infections was 7.8% (Ling *et al.*, 2015).

All hospitalized patients are at risk to acquire one of the Healthcare-Associated Infections, but patients in intensive care units (ICUs) are at higher risk of being infected compared to patients in general wards of the hospital (Edwardson and Cairns, 2019; Khan *et al.*, 2017a). WHO reports that in the ICU, the HAIs prevalence is 30% in high-income countries while in low and middle-income countries the HAIs prevalence is tended to be 2-3 times greater than in high-income countries (World

Health Organization, 2016b). The key explanation behind the high prevalence of HAIs among patients in ICUs can be referred to using invasive devices in ICUs for the treatment or monitoring of critically ill patients, putting them at greater risk of acquiring catheter-associated urinary tract infection (CAUTI), ventilator-associated pneumonia (VAP), central line-associated bloodstream infections (CLABSI) or other infections (Adegboye *et al.*, 2018).

The increasing in Healthcare-Associated Infections rates can be attributed to a number of risk factors, including lack of knowledge of infection prevention and control guidelines and evidence-based practice among healthcare staff; poor hygiene; lack of resources; inadequate nurse to patient's ratio; inadequate waste disposal; follow-up strategies (for health care staff); Immunosuppressed patients; length of stay; prolonged or inadequate use of antibiotics; catheters days (Adegboye *et al.*, 2018; Barker *et al.*, 2017; Khan *et al.*, 2017a).

As the majority of health care staff, nurses are considered as a backbone of the provision of healthcare to patients. They are the first healthcare professionals that patients see and play a significant role in health promotion and disease prevention, an in addition, nursing care is a crucial element of the patients' care plan. Their adherence extent with infection prevention and control precautions, relying on their evidence-based knowledge level, would either enable them to break the chain and prevent the spread of Healthcare-Associated Infections or be vectors, inadvertently, playing role in the transmission of disease-causing agents to themselves or to patients. Many studies have touched on the significant impact of inadequate knowledge about infection prevention and control precautions among nursing staff on increasing the prevalence of HAIs (Gandhi *et al.*, 2017; Giri *et al.*, 2016; Kadamwadi, 2016; Marofi *et al.*, 2017).

Studying nursing, whether at the undergraduate (baccalaureate) or diploma levels, cover a broad variety of subjects, including infection prevention and control, in order to efficiently protect patients and themselves from infections. In addition to the role of the educational institutions, hospitals through Continuous Nursing Education (CNE) provide their nursing staff with programs for the prevention and control of infections. However, the HAIs are still on the increase, and it is becoming necessary to develop a new strategy to tackle this critical problem.

Preventing Healthcare-Associated Infections needs to comply with standard precautions of infection prevention and control that should be applied in all situations of providing care for patients regardless of whether they have an infectious disease or not. In addition to the transmission-based precautions that should be implemented in certain cases when treating patients that are confirmed to have a certain type of infection. Many studies have identified barriers to compliance with infection prevention and control precautions. The most crucial barrier to understand the practices aimed at preventing Healthcare-Associated Infections is the low knowledge of infection prevention and control standard precautions concepts among healthcare providers (Adegboye *et al.*, 2018; Akagbo *et al.*, 2017).

Another barrier concluded in several studies to compliance with standard precautions of infections is the lack or inadequacy of personal protective equipment (PPE) which is an essential element in prevention and control of infections (Adly *et al.*, 2014; Naing *et al.*, 2001; Ogoina *et al.*, 2015).

Other studies have shown that the heavy workload of healthcare providers make compliance with standard precautions of infections is burdensome (Aluko *et al.*, 2016; Hu *et al.*, 2012).

An effective communication between nurses and doctors has a significant impact on ensuring the quality of patient care and on promoting patient safety (Amudha *et al.*, 2018). And as they are on the front line of patient care, nursing staff will have to collaborate with the physicians concerning their patients' treatment and follow up. Daily assessment of patients on invasive devices for early signs and symptoms of infections and the evaluation of the need to proceed with these devices is a critical task of nursing staff and the findings of their assessment must be reported to the attending physicians in order to facilitate decision-making in the patients care plan.

The prevention of HAIs requires significant training for healthcare workers, particularly nurses (Brusaferro *et al.*, 2015; Pegram and Bloomfield, 2015). Even with good knowledge about infection control, but nurses still have a well-noted gap with the practical aspect (Menegueti *et al.*, 2015).

This study focuses on increasing knowledge and practice awareness among critical care nurses in the prevention and control of infections to help reduce the prevalence of HAIs by developing and implementing a multi-modality module that promote evidence-based knowledge and knowledge-based practice. The core idea of the module based on promoting high exposure to infection prevention and control information through the use of multi-modality, including education sessions (power points slides), practical sessions (simulation), sharing information via e-mails, visual alerts (posters), quick-access and briefing materials (brochures), nursing guide to infection prevention and control book, infection control digital surveillance forms, electronic statistical tools, and facilitating communication channels with the hospital infection control unit and different healthcare workers.

1.3 Problem Statement

Healthcare-Associated Infections are a major concern of the healthcare sector as they have a detrimental effect on the quality of patient care and increase the economic burden due to prolonged hospital stay and excessive use of antibiotics in the treatment of infections. in Southeast Asia, the pooled incidence density of HAIs was 20 cases per 1000 ICU days, and the HAIs mortality rate ranged from 7% to 46%, while the excess length of stay of infected patients ranged from 5 to 21 days (Ling *et al.,* 2015), and the HAIs caused by multidrug-resistant gram-negative bacteria are prevalent among ICU patients and higher than reported in other regions (Teerawattanapong *et al.,* 2018). The critically ill patients who are treated in an Intensive Care Unit (ICU) have a high risk of having at least one of HAIs (Edwardson and Cairns, 2019) and in low and middle-income countries, device-associated infections in ICU are 13 times higher than in high-income countries (Allegranzi *et al.,* 2017).

Studies have shown that the implementation of proper preventive interventions can reduce HAIs. One of the effective preventive interventions that researchers mostly use is the implementation of an educational program related to one or more infection prevention and control competencies (e.g., hand hygiene) aimed at increasing knowledge and practice awareness among nursing staff (Chandak *et al.,* 2016; Haque *et al.,* 2018; Khan *et al.,* 2017a). Reviewing related literature revealed the need to extend their content to cover more topics needed to enhance the self-confidence and improve awareness and compliance with IPC guidelines among critical care nurses. To the best knowledge of the researcher, Microbiology, body defence mechanisms and immunity, and administration of hospital infection control are not commonly addressed along with IPC standard precautions and HAIs bundles

of care in a comprehensive education program, although they have a major effect on awareness and compliance with IPC precautions (Collins, 2008; Cox and Simpson, 2018; Durrant *et al.*, 2017; Vayalumkal and Martin, 2014). Another interventions also have been used to prevent HAIs such as antibiotic stewardship program (Murni *et al.*, 2020), developing organizational structures of responsibility (Brewster *et al.*, 2016), waste management and environment cleaning (Stout *et al.*, 2020). According to literature review, very limited studies focused on enhancing the role of critical care nurses in the daily assessment of patients with invasive devices or who underwent surgery, HAIs diagnosing, ensuring the appropriateness of antibiotics according to culture and sensitivity test results, and to participate in performing HAI-related statistics. The involvement of critical care nurses in such practices has a significant impact on their compliance with IPC precautions, increasing their self-confidence as a core member of patient care, improving the quality of care, and reducing HAIs.

Many studies illustrated the role of healthcare setting environment in HAIs, but few studies have introduced an intervention program to ensure a supportive environment for better IPC practices. Visual reminders (posters), availability of quick access guides (brochures), availability of hand hygiene and Personal Protective Equipment (PPE) supplements at the point of care, availability of different types of waste bags and sharp containers at the point of care, and clean environment are all infrastructure for better IPC practice and to encourage critical care nurses to comply with IPC precautions.

The multi-modality program might have a strong impact on the increase knowledge-based practice awareness that would boost the prevention of Healthcare-Associated Infections. The multi-modality program based on three major

interventions, includes infection control education program, infection control monitoring system, and infection control supporting environment, which will be implemented through multimodality, including education sessions, training sessions (simulation), sharing information via e-mail, visual reminders (posters), quick-access and briefed information sources (brochures), using digital follow-up and monitoring forms, and administration support. In Southeast Asia, studies that adopted multi-modality programs aimed at adult critical care nurses to improve their awareness and practice toward IPC to reduce HAIs are very limited. And to the best knowledge of the researcher, a multi-modality IPC program that integrates a comprehensive IPC education program, an IPC monitoring system, and an IPC supportive environment has not yet been implemented

So, the question arises, what is the impact of the multi-modality intervention infection control module in improving the practice level toward Healthcare-Associated Infections prevention and control among critical care nursing staff?

1.4 Study Area

The study was carried out in HUSM, a teaching hospital affiliated with Universiti Sains Malaysia, as well as a referral centre for Kelantan and nearby states.

HUSM has an infection control surveillance system, which was established in 2000 and promotes kinds of studies that related to the infection prevention and control by providing a pool of needed data. In addition to diagnosing of HAIs using the criteria specified by the CDC guidelines. HUSM has a well-staffed infection control department that collects infection control-related data using standardized protocols (Al-Talib *et al.*, 2010).

In HUSM, studies on the prevalence of HAIs, as well as knowledge and practice awareness among adult critical care nurses, are very limited, but some studies that

conducted in HUSM have highlighted the need for programs to prevent and control infections. One study that has been conducted in HUSM concluded the need to comply with proper hand hygiene techniques in which it was found that the microorganisms on the hands were more than 50 colony-forming units (CFU) in the 74% of ICU health care workers (Wong *et al.*, 2014). And in an observational prospective study, HUSM recorded 12.8% of patients who underwent general surgery developed an infection with the surgical site (Khan *et al.*, 2016). Another study revealed that the infection prevention and control protocols needed to be updated to prevent SSI in patients undergoing open heart surgery, in addition to the need for a post-operative monitoring system, especially for patients with diabetes (Leong *et al.*, 2017). Illustrating the challenging problem of Healthcare-Associated Infections in the development of Multidrug Resistance Organisms (MDROs) in the intensive care unit, a study conducted in HUSM reported the mortality rate caused by Carbapenem Resistant Acinetobacter (CRA) represent 13.6% of the overall mortality rate for ICU (Hassan *et al.*, 2020b).

1.5 The Rationale of the Study

In addition to the previously stated reasons for the need for such study in HUSM, Umscheid *et al.* found that evidence-based strategies can prevent 65%-70% of CLABSI and CAUTI cases, as well as 55% of VAP and SSI cases, and that this would have a positive impact on the cost of healthcare (Umscheid *et al.*, 2011). The burden of Healthcare-Associated Infections in developing countries is high and illustrates the need for infection prevention strategies to overcome this critical problem (Allegranzi *et al.*, 2011). Prevention of HAIs through infection control programs has very positive cost-benefit ratios (Arefian *et al.*, 2016). Health professionals play an important role in the prevention and control of HAIs through

the knowledge and practice of new infection control techniques (Sun, 2016). For example; knowledge and practice of hand hygiene techniques have a significant role in reducing HAIs (Hongsuwan, 2018).

The effect of high prevalence of HAIs can be explained by increase in mortality rate (Khan *et al.*, 2017b), increase in economic burden of healthcare due to prolong hospitalization (Lv *et al.*, 2019), and the treatment of HAIs with antibiotics, in addition to the high cost added to the patient care, will increase the risk of developing MDROs (Giraldi *et al.*, 2019; Teerawattanapong *et al.*, 2018).

High prevalence of HAIs are correlated with several factors: the availability of resources, knowledge of nursing staff and evidence-based practice of infection prevention and control precautions, monitoring and follow-up systems, and environment. And the most effective way to control HAIs and to reduce their prevalence is by an effective training and practices of infection prevention and control precautions (Singh *et al.*, 2012), improving the knowledge regarding infection prevention and control has significantly affected by effective education programs (Chandak *et al.*, 2018; Gaikwad *et al.*, 2018; McGaw *et al.*, 2012).

Nursing care is the majority of patients' care in ICUs and promoting their knowledge regarding infection prevention and control and reflecting this knowledge on their daily healthcare activities in the ICUs would come back with benefits on reducing the prevalence of HAIs.

To the best knowledge of the researcher, multi-modality are not commonly used in infection prevention and control programs aimed at nursing staff in ICUs that enhance high information exposure to alert them to infection prevention and control precautions and to easy their work by implementing an efficient follow-up system. In

addition, to date, no similar study has been reported in Malaysia. Hence the researcher would like to develop a multi-modality module taking in consideration three key factors; the knowledge and practice, follow-up system, and environmental factors to promote infection prevention and control practice among nursing staff in ICUs.

In conclusion, there is a need to develop an infection prevention and control program that would not only focus on educating critical care nurses' staff but also maintaining an appropriate and safe environment for practicing infection prevention and control strategies, in addition to setting up a clear and specific follow-up system for central lines catheters, surgical sites, indwelling urine catheters, and for patients on mechanical ventilators. There is a lack of such studies that consider many factors of HAIs, especially in Southeast Asia.

1.6 Significance of the Study

The research focused on developing an integrated, affordable, and non-pharmaceutical IPC module to enhance the knowledge and practice of critical care nurses to reduce HAIs. The significance of this study represented by:

1.6.1 Infection Control Education Program (ICEP)

A comprehensive IPC education program that provides the critical care nurse with the requisite evidence-based knowledge and encourages knowledge-based practice. The education program covers three clusters of IPC; (1) fundamentals to understand IPC which includes: microbiology of infection, body defence mechanisms, and administration of hospital infection control, (2) principles of IPC which includes: IPC standard precautions and IPC transmission-based precautions, and (3) specific IPC which includes Healthcare-Associated Infections (HAIs) with

four subtopics, including: CAUTI, CLABSI, VAP, and SSI. The Educational content was designed in an attractive style, enriched with practical reference illustrations, and published as the “Nursing Guide to Infection Prevention and Control” to be utilized as a reference for critical care nurses.

1.6.2 Infection Control Monitoring System (ICMS)

A follow-up system that promotes regular assessment practices in vulnerable patients, assesses the need for mechanical ventilators, central venous catheters, and urinary catheters to minimize the risk of HAIs arising from extended use, and regular assessment of the surgical site for early signs and symptoms of SSIs. ICMS introduces digital forms to decrease the workload of critical care nurses and to promote assessment and follow-up procedures, in addition to digital statistical tool that simplifies the performance of HAI-related statistics and summarizes the findings in infographics.

The ICMS instruction manual was designed in an attractive format and enriched with illustrations that clarify the steps of how to use and to fill out the digital forms and published to be used by critical care nurses.

1.6.3 Infection Control Supportive Environment (ICSE)

The third intervention that based on fostering a supportive environment that encourages critical care nurses to take IPC measures in the care of their patients. The ICSE concerned to develop visual reminders for IPC standard precautions that distributed in prominent places and quick-accessed informative brochures. In addition to assuring availability of hand hygiene supplements waste management equipment (e.g., bags and sharps containers) at the points of care.

The ICSE manual was developed and enriched with illustrations and released to be used by critical care nurses as a reference for their practice.

The ICEP, ICMS, and ICSE are combined into a single module named "Multi-modality Multimodality Infection Control" and abbreviated as MIMIC.

1.6.4 Evidence-based and Theory-based MIMIC module

The application of IM protocol facilitated the development of a module that addressed the needs of critical care nurses and helped to improve the HAI-related forms used in ICUs. IM protocol has also enhanced the adoption and implementation of the MIMIC module by the Hospital Management, Hospital Infections and Epidemiology Control Unit, Nursing Department, and critical care nurses. In support of the IM protocol, the adoption of SCT facilitated the development and implementation of MIMIC module and contributed to improving critical care nurses' self-confidence through applying theory-based teaching methods. The IM protocol supported by SCT reinforces the uniqueness of the developed MIMIC module as an integrated IPC program that tailored to the Adult ICUs' nurses.

1.7 Objectives

1.7.1 The General Objective

"To determine the Healthcare-Associated Infections prevalence and impact of "Multi-Modality Intervention Infection Control" module on knowledge and practice among critical care nursing staff in Hospital USM."

1.7.2 The Specific Objectives

The specific objectives of this study according to the study phases are as follows:

1.7.2(a) Phase I- Retrospective Study

i. To determine the prevalence of HAIs in the adult ICUs in HUSM.

ii. To determine the infection control system in the adult ICUs in HUSM.

1.7.2(b) Phase II- MIMIC Module

iii. To develop and validate the multi-modality intervention infection control module to improve knowledge and practice of HAIs prevention and control.

1.7.2(c) Phase III – Interventional Study

iv. To determine the knowledge scores and levels toward HAIs prevention and control among adult critical care nurses in HUSM.

v. To determine the practice scores and levels toward HAIs prevention and control among adult critical care nurses in HUSM.

vi. To determine the impact of MIMIC module on the knowledge scores toward HAIs prevention and control among adult critical care nurses in HUSM.

vii. To determine the impact of MIMIC module on the practice scores toward HAIs prevention and control among adult critical care nurses in HUSM.

1.8 Research Questions

The research questions of this study are as follows:

1.8.1 Phase I- Retrospective Study

i. What are the prevalence of HAIs in the adult ICUs?

ii. What are the improvements areas of the adult ICUs infection control system?

1.8.2 Phase II- MIMIC Module

i. Is the MIMIC a focused and valid module to improve the knowledge and practice toward Healthcare-Associated Infections prevention and control among critical care nursing staff?

1.8.3 Phase III – Interventional Study

i. What are the scores and levels of knowledge and practice towards Healthcare-Associated Infections prevention and control among critical care nursing staff?
ii. What is the impact of the "MIMIC" on improving the knowledge and practice scores toward Healthcare-Associated Infections prevention and control among critical care nursing staff?

1.9 Research Hypotheses

The research hypothesis for the study are as follows:

i. **H_1:** The MIMIC is a valid module for improving the knowledge and practice toward Healthcare-Associated Infections prevention and control among critical care nursing staff.

ii. **H_1:** There is a significant different score of knowledge towards Healthcare-Associated Infections prevention and control among critical nursing staff pre- and post-intervention.

iii. **H_1:** There is a significant different score of practice towards Healthcare-Associated Infections prevention and control among adult critical nursing staff pre- and post-intervention.

1.10 Operational Definitions

1.10.1 Intensive Care Unit

The intensive care unit (ICU), also known as critical care unit, is an advanced care facility that provides specialized medical and nursing care for critically ill patients who require close monitoring, support from high-tech medical equipment and devices, and specialized life-sustaining treatment (Marshall *et al.*, 2017).

1.10.2 Critical Care Nursing

Critical care nursing is a speciality in nursing focuses on the care of critically ill patients following life-threatening illness, injury, or surgery. The critical care nurse should have advanced skills through special training courses in relating to using of invasive devices such as mechanical ventilators (MV), central venous catheters (CVC) and urinary catheters (UC), monitoring, antibiotic treatment, ICU-related IPC measures, and special intensive care (Adam *et al.*, 2017; HealthWorkforce Australia, 2014; World Health Organization, 2003).

1.10.3 Healthcare-Associated Infections

An infection that develops in a patient in a hospital or other health care facility during the care process that was not present or incubating at the time of admission (World Health Organizatio, 2011).

1.10.4 Prevalence of HAI

The proportion of patients who have specific type of HAI at given point of time (point prevalence) or over a specified period of time (period prevalence) (CDC, 2012).

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter provides an overview of related literature on Healthcare-Associated Infections (HAIs). The literature review relied on four main aspects. The first aspect is to illustrate the characteristics of the ICU and the critical care nurses. The second aspect is to identify the core components of infection prevention and control programs and the barriers toward compliance with IPC practices. The third aspect is to understand the HAI by its definition, types, impacts, epidemiology, risk factors, and the need for preventive interventions with more focus on the interventions that applied worldwide to tackle this critical health problem. And the fourth aspect is the review of the Intervention Mapping (IM) protocol in the light of published literatures to assure its feasibility and suitability to develop the IPC interventions that fulfill the study objectives, and to review the implementation of the Social Cognitive Theory (SCT) in IPC education to improve the critical care nurse's awareness and practices.

Literature review was conducted to justify the need to develop affordable IPC interventions and to confirm the significance of the study in developing innovative IPC interventions tailored to adult critical care nurses and aimed at increasing their awareness and practice of the IPC guidelines and precautions to reduce HAIs.

2.2 Intensive Care Unit

The intensive care unit (ICU), also known as critical care unit, is an advanced care facility that provides specialized medical and nursing care for critically ill patients who require close monitoring, support from high-tech medical equipment and devices, and specialized life-sustaining treatment (Marshall *et al.*, 2017). Critically ill patients can be defined as patients with life-threatening illnesses that are

likely to result in morbidity and mortality in the absence of advanced medical interventions (Robertson and Al-Haddad, 2013) that are primarily based on the use of various invasive devices such as mechanical ventilators (MV), urinary catheters (UC), and central venous catheters (CVC) for monitoring, providing treatment, or assistance of body's organs function (Bennett *et al.*, 2018; Marshall *et al.*, 2017). The physical space of ICU is one of the main factors that support appropriate accommodation for patients' beds to allow access from all sides to provide patient care and effective implementation of IPC precautions in addition to medical devices and equipment placing (Marshall *et al.*, 2017).

2.2.1 Critical Care Nurse

Critical care nursing is a nursing specialty that focuses on the care of critically ill patients following life-threatening illness, injury, or surgery (HealthWorkforce Australia, 2014). Nurses are health care practitioners who have graduated from a certified nursing program that qualify them to practice patient care (CNANursing, 2019). With reference to the Nursing Program in School of Health Sciences at Universiti of Sains Malaysia (USM) as an example on Nursing Programs, a variety of courses are included in the nursing curriculum, which provide graduates with the knowledge and skills required to practice nursing care for patients and in accordance with IPC measures (School of Health Sciences, 2018). Along with the role of nursing programs in the graduation of qualified nurses at Diploma, Bachelor or Postgraduate level, critical care nurses should learn advanced skills through special training courses to provide care for critically ill patients who require invasive devices such as mechanical ventilators (MV), central venous catheters (CVC) and urinary catheters (UC), monitoring, long term antibiotic treatment, ICU-related IPC measures, and special intensive care (Adam *et al.*, 2017; World Health Organization, 2003).

Critical care nurses make up the largest proportion of critical care staff and sustaining the high quality of care provided to critically ill patients requires the implementation of continuing education programs to improve the knowledge and skills of critical care nurses (Cato and Murray, 2010; De Silva *et al.*, 2015).

2.3 Healthcare-Associated Infections (HAIs)

Healthcare-Associated Infections are a critical health problem that poses a health sector threat, have a major impact on morbidity and mortality rates, length of hospital stay, developing antibiotic-resistance microorganisms, and an increase in socio-economic burden (Khan *et al.*, 2017a).

2.3.1 Definition of Healthcare-Associated Infections

Healthcare Associated Infection (HAI), also known as hospital acquired infections or nosocomial infections, has been defined by many studies. HAI is defined by the World Health Organization (WHO) as an infection that develops in a patient in a hospital or other health care facility during the care process that was not present or incubating at the time of admission (World Health Organizatio, 2011). One study defined HAI as an infection acquired when providing health care in a hospital or in any other healthcare facility that first arise 48 hours or more after admission to hospital (Haque *et al.*, 2018). Another study identified HAIs as those developing 48 hours after admission to the hospital, 3 days after discharge or 30 days after surgery (Revelas, 2012). In conclusion, all HAI definitions have a common core concept, which is an infection acquired during hospitalization and not present or colonized at the time of admission and this concept distinguish HAI from another forms of infections.

2.3.2 Types of Healthcare-Associated Infections

The Centers for Disease Control and Prevention (CDC) developed a set of definitions to facilitate the surveillance of HAIs. The definitions reflect the criteria to diagnose HAIs based on clinical findings supported with laboratory results. According to the CDC set of definitions, HAIs have four common types; Catheter-Associated Urinary Tract Infections (CAUTI), Central Line-Associated Bloodstream Infections (CLABSI), Ventilator-Associated Pneumonia, and Surgical Site Infections (SSI) (Garner *et al.*, 1988).

2.3.2(a) Catheter-Associated Urinary Tract Infections (CAUTI)

According to the CDC, CAUTI is an infection correlated with a urinary catheter that affects any part of the urinary system, including kidney, ureters, bladder, and urethra (CDC, 2015). The urinary catheter is a tube inserted into the bladder to drain urine to an external bag either through the urethra and called indwelling catheter or through tiny hole in the abdomen and called suprapubic catheter (Jacquelyn Cafasso, 2018). Up to 80% of healthcare associated urinary tract infections are correlated with urinary catheter, and while it is known to be a key risk factor for UTIs, it is known to be the most preventable HAIs (Tenke *et al.*, 2017).

CDC identified certain criteria that should be met to diagnose CAUTI (CDC, 2020e), that include:

i. The indwelling urinary catheter had been in place for more than two consecutive days in an inpatient location on the date of event and was either:
    - Present for any portion of the calendar day on the date of event, OR
    - Removed the day before the date of event.

ii. Patient has at least one of the following signs and symptoms:

- Fever (>38^{o}C).
- Suprapubic tenderness with no other recognized cause.

And when the indwelling urinary catheter is removed, the patients' complaints are:

- Urinary urgency.
- Urinary frequency.
- Dysuria.

iii. No more than two types of causative agents identified by urine culture, at least one of which is bacterium of ≥105 CFU/ml.

These criterion elements should occur during infection window period (IWP) which is defined as the 7-day period during those all site-specific infection criteria should be fulfilled. It includes the collection date of the first positive diagnostic test that is used as an element to fulfill the site-specific infection criterion, the 3 calendar days before and the 3 calendar days after that (CDC, 2020b).

2.3.2(b) Central Line-Associated Bloodstream Infections (CLABSI)

CLABSI has been identified by the CDC as an infection when germs enter the bloodstream through the central line (CDC, 2011). The central line, also known as central venous catheter, is a tube that is often inserted through peripheral vein or central vein, most commonly the internal jugular, subclavian, or femoral vein, to provide access for giving medications or fluids, collecting blood for medical tests, renal replacement therapy, central venous pressure monitoring (Smith and Nolan, 2013). Four types of central lines are available (Table 2.1); the peripherally inserted central catheter (PICC), the implanted port (port-a-cath), the tunnelled catheter, and

the non-tunnelled catheter. And the selection of the central line type based on the expected duration of use and the indication for insertion (Smith and Nolan, 2013).

Table 2.1 Types of Central Lines (Smith and Nolan, 2013)

Type	Insertion site	Expected duration of use
Peripherally Inserted Central Catheter (PICC)	Brachial vein, basilic vein, cephalic vein	Medium term (weeks to months)
Implanted Port (Port-A-Cath)	Subclavian vein, internal jugular vein	Long term (months to years)
Tunnelled Catheter	Subclavian vein, internal jugular vein	Long term (months to years)
non-Tunnelled Catheter	Subclavian vein, internal jugular vein, femoral vein	Short term (days to 3 weeks)

CLABSIs are one of the critical Healthcare-Associated Infections that have significant impacts on mortality, morbidity and increasing economic burdens. Most of CLABSI cases can be prevented by effective aseptic procedures, management of the central line, and adopting efficient monitoring system (CDC, 2020a; Haddadin *et al.*, 2020).

CDC set out criteria that enable the healthcare professionals to diagnose CLABSI, including that:

i. The patient should has at least one sign or symptom of fever (>38^{o}C), chills, or hypotension.

ii. The causative agent identified by culture from two or more blood specimens obtained across different occasions.

iii. The organism found in the blood is not linked to another site infection.

These criterion elements should occur during IWP.

2.3.2(c) Ventilator-Associated Pneumonia (VAP)

VAP is a lung infection acquired by a patient who is mechanically ventilated (CDC, 2010b). In mechanical ventilation, an artificial airway (hollow tube) that is inserted through the mouth down into the trachea to help critically ill patient to breath while they are unable to breath by their own or when they are undergoing surgery and remains until the patient improves enough to no longer require it (Cleveland Clinic, 2019). The tube can also be placed in a patient's nose or through a hole in the front of the neck (CDC, 2010b). VAP is considered as one of the most common Healthcare-Associated Infections in ICU (Spalding *et al.*, 2017) and the prevalence of VAP reflects the safety and quality of care provided to critically ill patients in ICU (Álvarez-Lerma *et al.*, 2018).

The diagnoses of VAP could be difficult, as the manifestations and radiological test results can be correlated with many respiratory diseases (Timsit *et al.*, 2017). Table 2.2 shows the CDC criteria to be met by the healthcare professionals in diagnoses of VAP.