HEALTHCARE WORKER COMPLIANCE WITH DOCUMENTATION OF
INFECTION PREVENTION PROTOCOLS IN RELATION TO PATIENT
FACTORS OF WAR-WOUNDED U.S. SERVICE MEMBERS

by

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A Dissertation
Submitted to the
Graduate Faculty
of
George Mason University
in Partial Fulfillment of
The Requirements for the Degree
of
Doctor of Philosophy
Nursing

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Fall Semester 2012
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Healthcare Worker Compliance with Documentation of Infection Prevention Protocols in Relation to Patient Factors of War-Wounded U.S. Service Members

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DEDICATION

This dissertation is dedicated to my dear family. Primary thanks go to my beloved helpmate, John, and our wonderful children: Karen, Susan, and Hernán. Each one has loved and supported me throughout this lengthy educational journey. My greatest hope and inspiration throughout this voyage has been to demonstrate to my cherished grandchildren, Michael and Katelyn, that they can achieve their highest goals. While it may take more time than they thought, it might not be as simple as planned, and they may take numerous circuitous paths throughout their lives, they are worthy and capable of accomplishing whatever it is that they set out to do. If they ever have any doubts along the way, they can read this dedication and know that they can walk in Gramma’s footsteps and Gramma will be there to walk along with them.
ACKNOWLEDGEMENTS

I thank God for the gifts of the following relationships and enriching opportunities.

Thank you to my committee chair, Dr. Qiuping (Pearl) Zhou and wonderful committee members, Drs. Carol Q. Urban, Arnauld E.T. Nicogossian, and David Tribble, for sharing freely of their diverse expertise with me throughout the dissertation process.

I need to express deep appreciation for the continuous support and numerous opportunities offered so freely by CAPT Greg Martin, Navy Infectious Disease Service Lead, and Dr. David Tribble, Primary Investigator of the parent TIDOS study who also offered to be 3rd reader on my dissertation committee. This rich educational experience related to such an important topic was only possible through the initial suggestion of CAPT Martin and the steadfast contributions of Dr. Tribble that were all beyond the call of duty.

Thank you, Terri Rebmann, Ph.D., R.N., C.I.C., Associate Professor at Saint Louis University School of Public Health’s Institute for Biosecurity. Your constant support throughout the dissertation process as well as sharing your educational gifts greatly enhanced this study.

Finally, love and respect go to my dear mentor, Dr. Lewis W. Marshall. He encouraged me in countless ways via his collegiality, care, and support; initially as Infection Control Committee Chairman of the historic Columbia Hospital for Women in Washington, D.C. and more recently under his authority as Executive Board Member of Medicine for Peace. Thank you for years of boundless confidence in my work.
# TABLE OF CONTENTS

LIST OF TABLES .................................................................................................................. vii
LIST OF FIGURES .............................................................................................................. viii
LIST OF ABBREVIATIONS/SYMBOLS ........................................................................... ix
ABSTRACT ......................................................................................................................... xii

CHAPTER 1: INTRODUCTION..........................................................................................1
  BACKGROUND AND SIGNIFICANCE ........................................................................ 2
  STATEMENT OF THE PROBLEM ........................................................................... 4
  STATEMENT OF THE PURPOSE ........................................................................... 5
  RESEARCH QUESTIONS ............................................................................................ 6
  DEFINITION OF VARIABLES .................................................................................. 6
  CONCEPTUAL FRAMEWORK .................................................................................. 14

CHAPTER 2: REVIEW OF THE LITERATURE ..............................................................16

CHAPTER 3: METHODOLOGY .......................................................................................62
  OVERVIEW ................................................................................................................... 63
  RESEARCH DESIGN ................................................................................................... 63
  STUDY POPULATION AND SAMPLE FOR THE PROPOSED STUDY .................. 64
  DETERMINATION OF SAMPLE SIZE .................................................................... 66
  STUDY VARIABLES AND MEASUREMENT .......................................................... 67
  PARTICIPANTS .......................................................................................................... 82
  PROCEDURE FOR DATA MANAGEMENT/DATA ANALYSIS PLAN ....................... 83
  DATA COLLECTION TOOL AND PILOT TEST ...................................................... 85
  INFECTION PREVENTION COMPLIANCE DATA COLLECTION .......................... 90
  DATA SOURCE: TRAUMA INFECTIOUS DISEASE OUTCOMES STUDY (TIDOS) ................................................................................................................. 97
  HUMAN SUBJECT PROTECTION CONSIDERATIONS ......................................... 101
  DATA ANALYSIS ...................................................................................................... 102
  SUMMARY .................................................................................................................. 104
LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>TABLE 3.0: TIDOS ADMISSION NUMBERS</td>
<td>65</td>
</tr>
<tr>
<td>TABLE 3.1: STUDY VARIABLES</td>
<td>78</td>
</tr>
<tr>
<td>TABLE 4.0: PARTICIPANT DEMOGRAPHICS (n = 236)</td>
<td>107</td>
</tr>
<tr>
<td>TABLE 4.1: DESCRIPTION OF INPATIENT SEQUENCES</td>
<td>109</td>
</tr>
<tr>
<td>TABLE 4.2: COMPLIANCE WITH IP INTERVENTIONS</td>
<td>113</td>
</tr>
<tr>
<td>TABLE 4.3: LOGISTIC REGRESSION FOR ISO COMPLIANCE</td>
<td>116</td>
</tr>
<tr>
<td>TABLE 4.4: LOGISTIC REGRESSION FOR CHG COMPLIANCE</td>
<td>117</td>
</tr>
<tr>
<td>TABLE 5.0: CENSUS OF PARTICIPATING WARDS</td>
<td>124</td>
</tr>
</tbody>
</table>
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIGURE 1.0: CONCEPTUAL FRAMEWORK</td>
<td>15</td>
</tr>
<tr>
<td>FIGURE 3.0: INFECTION PREVENTION/CONTROL DATA COLLECTION FORM</td>
<td>70</td>
</tr>
<tr>
<td>FIGURE 4.0: EVOLUTION OF ISOLATION PRECAUTIONS FINDINGS</td>
<td>111</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Full Form</td>
</tr>
<tr>
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<td>-----------</td>
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<tr>
<td>ABC</td>
<td>Acinetobacter baumannii-calcoaceticus complex</td>
</tr>
<tr>
<td>AIS</td>
<td>Abbreviated injury scale</td>
</tr>
<tr>
<td>ASC</td>
<td>Active surveillance culture</td>
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<td>AST</td>
<td>Antimicrobial susceptibility testing</td>
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<td>BSI</td>
<td>Bloodstream infection</td>
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<td>BAMC</td>
<td>Brooke Army Medical Center</td>
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<td>BUMED</td>
<td>Bureau of Medicine and Surgery</td>
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<td>CDC</td>
<td>Centers for Disease Control and Prevention</td>
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<tr>
<td>CHG</td>
<td>Chlorhexidine gluconate</td>
</tr>
<tr>
<td>CRF</td>
<td>Clinical report form</td>
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<tr>
<td>CFR</td>
<td>Code of Federal Regulations</td>
</tr>
<tr>
<td>CLABSI</td>
<td>Central line-associated bloodstream infection</td>
</tr>
<tr>
<td>CONUS</td>
<td>Continental United States</td>
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<tr>
<td>CTR</td>
<td>U.S. Navy-Marine Corps Combat Trauma Registry</td>
</tr>
<tr>
<td>Cx</td>
<td>Culture</td>
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<tr>
<td>DCC</td>
<td>Data Coordinating Center</td>
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<tr>
<td>DHHS</td>
<td>Department of Health and Human Services</td>
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<td>DHQP</td>
<td>Division of Healthcare Quality Promotion</td>
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<tr>
<td>DMSS</td>
<td>Defense Medical Surveillance System</td>
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<tr>
<td>DoD</td>
<td>Department of Defense</td>
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<td>DoN</td>
<td>Department of Navy</td>
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<tr>
<td>EMR</td>
<td>Electronic Medical Record</td>
</tr>
<tr>
<td>ESBL</td>
<td>Extended spectrum beta (β)-lactamase</td>
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<tr>
<td>FRSS</td>
<td>Forward Resuscitation Surgical System</td>
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<tr>
<td>FST</td>
<td>Forward Surgical Team</td>
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<tr>
<td>Gm (-)</td>
<td>Gram negative</td>
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<tr>
<td>Gm (+)</td>
<td>Gram positive</td>
</tr>
<tr>
<td>GMU</td>
<td>George Mason University</td>
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<tr>
<td>GNB</td>
<td>Gram negative bacilli</td>
</tr>
<tr>
<td>GPC</td>
<td>Gram positive cocci</td>
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<tr>
<td>DMSS</td>
<td>Defense Medical Surveillance System</td>
</tr>
<tr>
<td>HAI</td>
<td>Healthcare-associated infection</td>
</tr>
<tr>
<td>HICPAC</td>
<td>Hospital Infection Control Practices Advisory Committee</td>
</tr>
<tr>
<td>HIPAA</td>
<td>Health Insurance Portability Authorization Act</td>
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<tr>
<td>HSRB</td>
<td>Human Services Review Board</td>
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USAF ................................................................. U.S. Air Force
USMC ................................................................. U.S. Marine Corps
USN ................................................................. U.S. Navy
USUHS ........................................ Uniformed Services University of the Health Sciences
UTI ................................................................. Urinary tract infection
VA ................................................................. Veteran’s Administration
VAP ................................................................. Ventilator-associated pneumonia
WRAIR ............................................................ Walter Reed Army Institute of Research
WRAMC .......................................................... Walter Reed Army Medical Center
WRNMMC ......................................................... Walter Reed National Military Medical Center
ABSTRACT

HEALTHCARE WORKER COMPLIANCE WITH DOCUMENTATION OF INFECTION PREVENTION PROTOCOLS IN RELATION TO PATIENT FACTORS OF WAR-WOUNDED U.S. SERVICE MEMBERS

Judith Fay Boylan English, Ph.D.
George Mason University, 2012
Dissertation Director: Dr. Qiuping (Pearl) Zhou

The purposes of this pilot study were to 1) examine the documented compliance to infection prevention procedures in the electronic medical record (EMR) by healthcare providers caring for war-wounded U.S. service members, and 2) assess patient factors that related to compliance. It was an observational retrospective cohort study of EMRs between June 1, 2009 and May 31, 2011. The study identified documentation of provider compliance / noncompliance with 1) active surveillance cultures (ASC), 2) isolation (ISO) precautions, and 3) administration of chlorhexidine gluconate (CHG) baths in relation to available patient factors from the Trauma Infectious Diseases Outcomes Study (TIDOS) data. A survey form was devised to gather compliance data related to ISO precautions and CHG baths documented in each subject’s EMR. A total of 236 traumatic U.S. war-wounded EMRs were surveyed covering 489 inpatient Sequences of
Admission, Transfer, or Readmission. 226 (95.8%) of ASCs obtained upon Admission were fully compliant with the protocol that required submission of groin cultures to detect Gm (-) multidrug resistant organisms (MDROs) and other potentially transmissible pathogens within the first 48 hours following admission. Documentation of adherence to protocols related to ISO was 61.4% and administration of CHG cloth baths was 56.9%. The overall logistic regression model for patient factors related to ISO compliance (n = 286) was not statistically significant ($\chi^2 = 3.7$, $df = 5$, $p = 0.59$). CHG bath administration compliance was also not statistically significant ($\chi^2 = 10.87$, $df = 5$, $p = 0.054$).

Infection Preventionists were more likely to document the initiation of ISO via Contact Precautions, responsible for most of the Progress Notes/Nursing Orders (90.3%, n = 334) communicating the need for Isolation Precautions to be initiated plus Progress Notes/Nursing Orders (90.5%, n = 306) communicating no further need for Isolation Precautions.

Replication of this pilot utilizing the entire number of 599 war-wounded would help validate findings of this study. Additionally, hospitals need to rapidly progress in standardization of basic clinical content in the EMR in relation to evidence-based practices. Standardization will result in capabilities for Nursing, Infection Prevention, Medical Staff, Risk Management and Quality Improvement to query the EMR for compliance reports on best practices that are necessary for ever-increasing demands to provide transparency and target zero healthcare-associated infection rates.

*Keywords:* infection prevention, compliance, Gm (-) MDRO, war-wounded, TIDOS, electronic medical record
CHAPTER 1: INTRODUCTION
CHAPTER 1: INTRODUCTION

BACKGROUND AND SIGNIFICANCE

Within one month of the United States military invasion of Iraq in 2003 Commander Kyle Petersen, the sole infectious diseases physician onboard the hospital ship USNS Comfort in the Persian Gulf, emailed for support of an outbreak of multidrug resistant Acinetobacter baumannii, a Gram negative multidrug resistant (Gm (-) MDR) pathogen sweeping through the intensive care units (personal communication, April 2003). Based on culture results of blood and other normally sterile body substances, he had initiated empiric transmission-based isolation precautions for all patients exhibiting symptoms of possible infection and was treating them with imipenem, the only antibiotic to which the infection was sensitive. He was rapidly running through his entire supply of alcohol hand-rub and imipenem while increasing numbers of critically ill patients were being admitted with or developing healthcare associated infection due to MDR Acinetobacter baumannii. He asked for emergency supply delivery of alcohol-based hand-rub and imipenem as well as a literature review of Acinetobacter baumannii to initiate a protocol that would successfully break the chain of infection. Consequently, a cache of alcohol hand-rub and imipenem was sent via FedEx to the USNS Comfort, delivered via helicopter on the very day that the infectious disease physician would have
to have initiated rationing of imipenem due to dwindling supplies (FedEx was delivering more quickly than military pouch). Extraordinary infection prevention measures were taken to protect all patients and healthcare personnel from continuing healthcare associated infections. Simultaneously in Bethesda, Maryland at the National Naval Medical Center, all war-wounded individuals were screened for *Acinetobacter baumannii* and empirically placed on Contact Precautions until their screening cultures were negative for *Acinetobacter baumannii* or other transmissible infection.

Concerns related to Gm (-) MDR healthcare associated infections have not been limited to military hospitals, but also plague civilian public and private facilities worldwide. The 2010 Institute of Medicine (IOM) report (Choffnes, Relman, & Mack, 2010) was dedicated to antibiotic resistance and implications for global health and novel intervention strategies. They predict likely raises in healthcare costs over the next five to ten years via two-pronged increases in wealth and access to antimicrobials in developing countries that will save lives in some places while vastly increasing MDROs where antimicrobials are used inappropriately. Their advice to prevent both development and spread of MDROs is to train providers in good prescribing practices, support public education campaigns, and improve infection control in communities and throughout healthcare. Their Strategies to Address Antimicrobial Resistance (STAAR) Act, backed by the Infectious Disease Society of America (IDSA), bolsters existing surveillance, data collection, and research. It urges strengthening of public health infrastructure as essential to long-term management of antibiotic resistant diseases in settings i.e., hospitals, clinics, veterinarians’ offices, and animal production operations.
According to Douglas Scott (2009), compliance to infection prevention protocols is important due to tremendous medical costs associated with healthcare-associated infections. Scott cites three components of cost related to socio-economic costs of healthcare associated infection; not only direct medical costs in dollars, but the indirect costs related to worker productivity and non-medical costs, plus intangible costs related to diminished quality of life.

This dissertation will study healthcare worker compliance to infection prevention protocols as documented in the electronic medical record including 1) active surveillance cultures, 2) clearance cultures/transmission-based isolation precautions, and 3) CHG baths of U.S. war-wounded upon return to continental United States from Iraq and Afghanistan. These topics have not previously been sufficiently investigated.

STATEMENT OF THE PROBLEM

Given the limited treatment options for Gm (-) MDR infections (Choffnes, Relman, & Mack, 2010; Harris & Thom, 2010; Siegel, Rhinehart, Jackson, & Chiarello, 2006; Petersen et al., 2007; Fridkin et al., 2002; McGowan, 2004), prevention of such infections is critical to decrease their incidence and consequences. An important basic strategy for prevention is the compliance with infection prevention protocols by healthcare providers (Choffnes et al., 2010; Siegel et al., 2006; Siegel, Rhinehart, Jackson, & Chiarello, 2007). Indeed, many Gm (-) MDR infections occurring in the hospitals were related to the inappropriate practices of healthcare providers (Whitman et al., 2008). However, the extent of compliance of healthcare providers to the infection
prevention protocols has not been sufficiently investigated and there is a lack of data regarding their compliance and related factors.

In a recent prospective, longitudinal cohort study of hospitalized inpatients medically evacuated from Iraq and Afghanistan to Walter Reed Army Medical Center (WRAMC) in Washington, D.C., Weintrob et al. (2010) identified that colonization with Gm (-) MDR organisms is not just common among patients with war-related trauma admitted to the military hospital, but also occurs among non-deployed patients in military hospitals with recent healthcare contact. The concerns related to healthcare associated spread of Gm (-) MDRs within hospitals that were initially identified upon the invasion of Iraq continue. Those concerns result in the need for studies to identify and examine potential predictors of such infections in U.S. war-wounded, in particular the compliance with infection prevention protocols by healthcare providers.

**STATEMENT OF THE PURPOSE**

The purposes of this study are to 1) examine the documented compliance to infection prevention procedures by healthcare providers caring for war-wounded U.S. service members, and 2) assess patient factors that relate to compliance.

Dependent variables (DVs) include compliance with the documentation of infection prevention protocols involving 1) active surveillance cultures (ASC), 2) isolation (ISO) precautions, and 3) chlorhexidine gluconate (CHG) cloth bathing to decolonize. The independent variables (IVs) include patient's age, country of deployment at time of injury, length of time from date of injury to date of admission to participating
hospital (days), severity of injury assessment, sequential organ failure assessment
(SOFA), presence/absence of infectious co-morbidities, type of injury, anatomic site of
injury, and resulting infectious disease events (stratified by presence/absence of Gm (-)
MDR pathogens).

**RESEARCH QUESTIONS**

The following research questions will be addressed:

1. What is the documented compliance rate to the infection prevention protocols
regarding 1) ASC, 2) ISO, and 3) CHG bath decolonization by healthcare providers
caring for U.S. war-wounded?

2. What patient factors are associated with compliance with the ASC procedure?

3. What patient factors are associated with compliance to clearance cultures/isolation
procedure?

4. What patient factors are associated with compliance to the CHG bathing?

For research questions 2 to 4, the patient factors considered include age, country
of deployment at time of injury, length of time from date of injury to date of admission to
participating hospital (days), SOFA, type of injury, anatomic site of injury, and infection.

**DEFINITION OF VARIABLES**

Compliance is an act or process of complying with a demand or recommendation
Compliance is also defined as 1) the act of complying with a wish, request, or demand;
acquiescence; plus, in Medicine, 2) the willingness to follow a prescribed course of treatment (The American Heritage Dictionary, 2009). Compliance is defined as adherence of personnel working within governing agencies/bodies to an official mandate or obligatory standard (McGraw-Hill Concise Dictionary of Modern Medicine, 2002). For purposes of this study, compliance is documentation in the electronic medical record that a healthcare provider has adhered to infection prevention protocols to obtain ASCs upon admission; initiate, maintain, and potentially discontinue Contact Precautions; and administration of CHG cloth bathing per National Naval Medical Center (NNMC) and Walter Reed Army Medical Center (WRAMC) Gm (-) Clearance Culture and CHG Bath protocols following consultation with the Centers for Disease Control and Prevention (CDC).

ASCs are defined as targeted microbiological screening cultures of patients admitted to a hospital to control the increasing numbers of infections due to multidrug-resistant organisms (McGinigle, Gourlay, & Buchanan, 2008). By Military Medicine protocol initiated in 2006 by joint agreement between NNMC, WRAMC, and Brooke Army Medical Center (BAMC) Infectious Diseases and Infection Prevention/Control Services, all U.S. war-wounded are required to have ASCs obtained upon admission to Trauma Infectious Diseases Outcomes Study (TIDOS)-participating hospitals to rule out colonization and/or infection with MDROs.

CDC’s MDRO Guidelines by Siegel et al. (2006, pp. 25-26) describe reasonable protocols for the possibility of clearing patients colonized with MDROs for prolonged
periods of time, thus enabling individuals who are no longer shedding such pathogens to be safely removed from Contact Precautions isolation. They point out a paucity of information in the literature regarding Gm (-) MDRs while advising that if there is no decolonization of such patients, it is logical to assume that Contact Precautions should be used for the duration of stay in the setting in which they were first implemented. They advise that it would be reasonable to discontinue such precautions when ≥3 surveillance cultures for the targeted MDRO are repeatedly negative over the course of a week or two in a patient who has not received antimicrobial therapy for several weeks, particularly in the absence of a draining wound, profuse respiratory secretions or evidence implicating the individual patient in ongoing transmission of the specific MDRO within the facility. Since 2008 all four military treatment facilities in the Trauma Infectious Diseases Outcomes Study (TIDOS) have agreed to comply with MDR Gm (-) Clearance Culture Protocol. This includes collection of ASCs, adherence to Contact Precautions isolation, repeated cultures after decolonization or effective antibiotic therapy has been discontinued for the appropriate number of hours, and discontinuation of precautions after three consecutive sets of cultures at least 72 hours apart are finalized as negative.

The CDC MDRO Guidelines (Siegel et al., 2006) report that MDRO decolonization entails treatment of colonized subjects to eradicate carriage of such pathogens, but with varying degrees of success. The recommended protocols consist of a variety of regimens including topical antimicrobial ointments alone or in combination with oral antibiotics, plus the use of antimicrobial soap for bathing. They report that
while such regimens are not sufficiently effective to merit routine implementation, the protocols do have limited use in outbreaks and other high prevalence situations.

O’Fallon, Gautam, and D’Agata (2009) relate their arbitrarily chosen definition of colonization clearance as two serial cultures without recovery of Gm (-) MDR organisms may not accurately reflect clearance, but since the same strain of Gm (-) MDR was not recovered from any subsequent cultures performed after the definition of clearance was met, it was suggestive that sampling error was not likely to explain clearance of Gm (-) MDR species.

Since 2008 the National Naval Medical Center and Walter Reed Army Medical Center, after consulting with the Centers for Disease Control and Prevention (CDC), initiated the following protocols:

ASC: Active Surveillance Cultures should be taken from original site plus bilateral groin (laboratory chit marked “MDRO GROIN”) for *Acinetobacter baumannii* (ACB)

ASC should also be taken from original site plus urine or peri-anal/rectal swab (Laboratory chit marked “r/o ESBL”) for (*Klebsiella*, *Pseudomonas*/ *Burkholderia/Stenotrophomonas*, *E. coli*, *Enterobacter*, *Proteus*, *Salmonella*, or *Serratia*) ESBLs and/or *Klebsiella pneumoniae* carbapenemases (KPCs),

In order to clear patient colonized/infected with Gm (-) MDRO, the patient must meet all of the following criteria:

1. Must be off effective antimicrobial therapy at least 72 hours (one to which the pathogen is sensitive).
2. Obtain three consecutive cultures at the sites directed above at least 72 hours apart.

3. All culture results must be finalized as negative prior to discontinuing Contact Precautions.

**Isolation (ISO):** Placed on Contact Precautions in a private room or cohort with another patient with the same pathogen and no other likely colonization/infection until appropriately obtained ASCs are finalized as negative for Gm (-) MDROs by Microbiology Laboratory.

**CHG Bath:**

- Intensive Care Unit
  - All OIF/OEF admissions will receive a chlorhexidine gluconate (CHG) cloth bath upon arrival to the ICU
  - CHG baths will be administered every 3rd day until final surveillance cultures are returned as negative for Gm (-) MDROs from Microbiology Laboratory

- Traumatic Brain Injured (TBI) Patients on Wards
  - Upon arrival to Ward, all OIF/OEF patients with suspected or diagnosed TBI who are colonized with Gm (-) MDR are bathed with CHG wipes daily for five consecutive days
• Wait 24 hours following the last CHG bath has been administered before obtaining bilateral groin cultures to rule out continued colonization with ACB
• Wait 24 hours following the last CHG bath has been administered before obtaining urine or peri-anal/rectal swab culture to rule out continued colonization with ESBLs

Definitions of independent variables in this study were as follows:

Age in years is equal to the current year minus birth year provided by the Joint Theater Trauma Registry.

Theater of deployment is Afghanistan, Iraq, or other.

Length of time before admission to continental U.S. is calculated in days via the date of admission to National Naval Medical Center minus the date of injury.

Severity of injury is an injury and severity scoring (ISS) anatomic classification provided by Joint Theater Trauma Registry, as calculated in Landstuhl Regional Medical Center, Germany (Linn, 1995). This is ordinal level data equal to the sum of squares for the highest values in each of the three most severely injured body regions (range 1-75).

SOFA describes morbidity and has demonstrated value in serial measurements and is a reliable indicator of prolonged length of stay and death in trauma patients
(Vincent et al., 1996). It is assessed upon ICU admission plus weekly and is available from Level 4/5 hospitals, specifically from LRMC and NNMC for this study.

Infectious co-morbidities (Tribble et al., 2010, p. 31) are obtained via ID Module data with the assumption of higher risk of infection with a greater number of co-morbidities.

Type of injury is blast or nonblast per ID MODULE DATA with the assumption that contaminated or dirty wounds put injured at greater risk of Gm (-) MDR infection (Tribble et al., 2010, p. 17).

Anatomic site of injury is obtained using International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes as tabulated by ID MODULE DATA in the electronic medical record that include the following: traumatic brain injury (TBI); other head, face and neck; spinal cord injury (SCI); vertebral column injury (VCI); torso; upper extremities; lower extremities; other & unspecified; and system-wide. The system assumes a higher level of risk for infection with contaminated or dirty wounds and penetration of the gastrointestinal tract. Tribble et al. (2011) describe how the ID MODULE DATA captures ICD-9th Revision codes for any injury sustained by patients during a traumatic injury. They represent similar injury types such as “skin/soft tissue injury, no open fractures,” “skin/soft tissue injury with open fractures, exposed bone, or open joints,” stratified by “Injury Pattern” Codes representing solitary or multiple injuries as detailed in Table 3.1: STUDY VARIABLES, page 78.
Infection is determined via specific site per TIDOS (Tribble et al., 2010) infectious disease event definitions and CDC/National Healthcare Safety Network (NHSN) criteria for infection (Horan, Andrus, & Dudeck, 2008). It is then stratified by specific Gm (-) MDR pathogen via classification of antibiotic susceptibility results in accordance with Clinical and Laboratory Standards Institute (CLSI) guidance (Sunenshine et al., 2007). The 2007 Healthcare Infection Control Practices Advisory Committee (HICPAC) isolation guidelines for healthcare facilities require that Contact Precautions be utilized in settings with evidence of ongoing transmission, in acute care settings with increased risk for transmission, and during contact with patients with wounds that cannot be contained by dressings.

Multidrug resistance is the resistance of bacteria against more than two antibiotics that were once effective (Mosby’s Medical Dictionary, 8th Ed., 2009). Increasing rates of multidrug resistant pathogens among war-wounded personnel lead to an important consideration of categorizing antibiotic susceptibility for a given bacteria-antibiotic combination plus what comprises multidrug resistance for a particular pathogen (Tribble et al., 2010). Multidrug resistance among Gram-negative bacteria is defined as resistance or intermediate susceptibility to $\geq 3$ of the following antimicrobials/antimicrobial groups: 1) ampicillin-sulbactam or piperacillin-tazobactam, 2) meropenem, 3) ceftazidime or ceftriaxone, 4) ciprofloxacin, and 5) gentamicin, using breakpoint values defined by Clinical and Laboratory Standards Institute (2006).
CONCEPTUAL FRAMEWORK

The conceptual framework of this study has evolved from the researcher’s work as a civilian infection preventionist employed by the U.S. Navy throughout Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) (see FIGURE 1.1: CONCEPTUAL FRAMEWORK, page 15). In this capacity the researcher was consulted regarding healthcare-associated infections (nosocomial infections) due to Gm (-) MDR Acinetobacter baumannii beginning with the first documentation of such an outbreak in Department of Defense (DoD) active duty personnel shortly after the United States military invaded Iraq in 2003, and published by U.S. Navy Medicine. This study was an attempt to document what infection prevention protocols were recorded in the electronic medical record throughout a two year time period and what patient-related and/or facility-related factors may help to explain it. The study looked for correlation of healthcare provider compliance to documentation of infection prevention protocols in the electronic medical record with independent variables including both individual patient characteristics and injury-related factors. The study looked for odds for recurrence of infection and the incidence of healthcare-associated infection within the sample facility, looking at prevalence and correlates. It also identified monthly patient census and staffing levels of the participating units.
Conceptual Framework

Individual Characteristics

Injury-Related Factors

Provider Compliance

Organizational Level
Monthly Census/Seasonality
Staffing Level

Odds for Recurrence of Infection
Incidence of HAI in Facility

Documentation ↔ Compliance
Percentage of Agreement

FIGURE 1.0: CONCEPTUAL FRAMEWORK
CHAPTER 2: LITERATURE REVIEW
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A retrospective review of medical records were searched electronically for patients who had gone primary implantation of spinal cord stimulators (SCS) and intrathecal drug delivery systems (IDDS) to document compliance with infection prevention measures. It was initiated following an outbreak of infections associated with SCS or IDDS in the research hospital (Burgher, Barnett, Obray, & Mauck, 2007). The Institutional Review Board awarded approval by the Division of Pain Medicine after they had solicited guidance from the Division of Infectious Diseases and Cardiology Pacemaker Implantation Service as well as technical support services. The study included electronic review of records specifically related to device revision (primary implantations were excluded) between January 1, 2002 and December 31, 2006. Interventions included: 1) traditional air exchange operating room venue, 2) perioperative intravenous antimicrobial prophylaxis, 3) patient antiseptic bathing the evening before and morning of surgery, 4) 10-minute scrub of surgical site with chlorhexidine followed by povidone-iodine paint, 5) double gloving of operative personnel, 6) optimal scrub procedure classes & anatomy-based suturing instruction for all pain fellows, and 7) intraoperative wound irrigation with an antibiotic-containing solution. Measurement of compliance with infection prevention and infection incidence included: 1) antiseptic skin preparation patient instructions (before 3.0%, after 66.1%, \( P < 0.0001 \)), pre-incision antimicrobial
duration (before 5.9%, after 40.7%, \( P = 0.0002 \)), pre-incision antimicrobial type [i.e., chlorhexidine \&/or iodine-based] method (before 66.7%, after 42.4%, \( P = 0.05 \)), 2) operating room (before 58.5%, after 100%, \( P < 0.0001 \)), 3) prophylactic antibiotic administered (before 88.2%, after 94.8%, \( P = 0.4 \)), correct dose (before 58.8%, after 67.2%, \( P = 0.5 \)), 3) surgical wound irrigation with saline (before 78.8%, after 93.1%, \( P = 0.008 \)), antibiotic solution (before 55.9%, after 93.1%, \( P < 0.0001 \)), 4) incidence of infection before 11.2%, after 1.7%, \( P = 0.06 \)). Researchers concluded that because several safety measures were introduced simultaneously, infection prevention compliance was not as complete as had been anticipated. They suggest that there was an increase in the probability of performance of infection prevention elements, but advise that an additional mechanism to ensure compliance via reminder and recorder of performance could improve adherence and facilitate future review of their practice.

Siow, Bryce, and Scharf (2009) studied healthcare workers’ perceived compliance to respiratory and gastrointestinal algorithms for management of patients in emergency care settings. They did cross sectional surveys in two emergency departments in British Columbia, Canada during the month of July 2008, distributed to personnel based on the relative size of the departments (100 at the 955-bed adult tertiary care teaching hospital and 50 at the 355-bed community hospital), both of which provided 24-hour emergency services. Surveys requested reporting on compliance as well as other concerns related to the respiratory and gastrointestinal algorithms on 5-point Likert scales. A total of 96 (64%) of the surveys were returned, 53 (53%) from the larger facility and 43 (86%) from
the smaller one, suggesting results were likely representative of healthcare personnel in
the emergency departments surveyed. RNs were the most represented group at 70.5% and
physicians were nearly 10% of respondents, reflecting the occupational distribution in the
departments. Healthcare personnel reported agreement between expected and actual use
of both respiratory and gastrointestinal algorithms (applied to one to five patients per
shift that was also the number of eligible patients). Global mean scores for compliance
(3.3 for larger facility and 3.5 for smaller facility) for both respiratory and gastrointestinal
algorithms. Differences for compliance ($P = .001$) of the respiratory algorithm were
observed between facilities with the larger facility showing significantly higher scores.
Physicians reported lower compliance with respiratory algorithm than other healthcare
personnel ($P = .03$ compared with RNs, and $P = .02$ compared with other clinical staff).
The researchers concluded that their findings suggest workers believe algorithms offer a
clear and consistent approach to patient management, assisting in protecting patients and
colleagues despite environmental and resource limitations.

In 2007 Shigayeva et al. published a study assessing factors associated with
healthcare personnel compliance to recommended barrier precautions while caring for
critically ill patients who were intubated and artificially ventilated due to severe acute
respiratory syndrome (SARS). The retrospective cohort study of 15 acute care hospitals
in Ontario, Canada was conducted via standardized interviews. Of 879 eligible healthcare
personnel, 795 (90%) participated. Using multivariate analysis the following predictors of
consistent compliance to recommended barrier precautions were identified: 1)
recognition of patient as a SAR case (odds ratio [OR], 2.5 [95% CI, 1.5-4.5]); 2) OR for passive training, 1.7 [95% CI, 1.0-3.0]), and 3) working in a SARS unit (OR, 4.0 [95% CI, 1.8-8.9]) or intensive care unit (OR, 4.3 [95% CI, 2.0-9.0]). Factors associated with significantly lower rates of consistent compliance included 1) the provision of care for patients with higher Acute Physiology and Chronic Health Evaluation (APACHE) II scores (OR for score APACHE II of 20 or greater, 0.5 [95% CI, 0.28-0.68]) and 2) work on shifts that required more frequent room entry (OR for ≥6 entries per shift, 0.5 [95% CI, 0.32-0.86]). Researchers concluded that healthcare personnel compliance to self-protection guidelines most closely tied to whether they provided care to patients with a definitive diagnosis of SARS. They also related non-adherence rates to inadequate knowledge regarding communicable diseases and modes of transmission due to discrepancies between what healthcare personnel believe they know and what they actually know about protecting themselves from infection.

Gammon, Morgan-Samuel, and Gould (2007) reviewed 37 studies (24 related to measuring healthcare personnel compliance and 13 evaluated the effect of research intervention on compliance) plus other studies included that examined specific reasons for non-compliance or infection prevention precautions in general. Literature review was done using electronic databases from 1994 to 2006 with a number of key terms utilized. Each of the 13 studies of practice innovations and interventions to improve compliance with Universal or Standard Precautions (using barriers to avoid contact with moist body substances) concluded that compliance improves following a planned and structured
intervention, but fail to demonstrate any permanent, longer term compliance. They advise future research should examine the lasting effects of a research intervention on compliance and evaluate if or when compliance after a research intervention returns to pre-intervention baseline levels. They cite that healthcare personnel are selective in their adherence to precautions and compliance to certain elements.

In 2005 Berhe, Edmond, and Bearman conducted an anonymous survey of intensive care unit healthcare personnel at an 820-bed, 9 ICU tertiary care medical center. 324 individuals responded of 820 questionnaires distributed (40%), of whom 10% were attending physicians, 31% resident physicians, 36% registered nurses, 9% licensed practical nurses and patient care assistants, and 14% others (medical students, respiratory therapists, physical and occupational therapists, social workers). Sixty-nine percent of respondents reported performing hand hygiene before and after patient contact >80% of the time, 65% reported >80% compliance with contact precautions and 80% reported >80% compliance with airborne isolation precautions. Sixty-two percent of physicians and 77% of registered nurses reported performing handwashing >80% of the time before and after patient contact ($P = .02$). Physicians comparing themselves with non-physicians were more likely to report their individual compliance with hand hygiene ($P <.001$), contact precautions, ($P = .026$), and airborne isolation ($P = .011$) was better than their peers. Incentive for compliance with isolation guidelines differed by group. Registered nurses were inspired by patient safety more than personal safety to comply with contact isolation compared with licensed practical nurses or patient care assistants and other non-
physicians (\(P = .001\)). Differing from attending physicians and registered nurses, resident physicians reported personal safety more than patient safety as a reason to practice contact precautions. Perceived causes for healthcare-associated infections were distributed equally among respondents among all respondents and included cross transmission, extrinsic host factors, and intrinsic host factors. Also, regardless of their perceptions of etiology, the majority of respondents cited >40% of all healthcare associated infections are preventable. Several respondents felt that cross transmission of pathogens is both pathogenic and preventable. Since healthcare personnel perceptions of compliance with infection prevention practices, healthcare-associated infection transmission, and motivation for compliance differ by occupational category; the researchers suggest that educational programs should be tailored according to occupation.

Bryce, Copes, Gamage, Lockhart, and Yassi (2008) audited resources available to infection control and occupational health in order to promote safe work behavior and compare actual resources with healthcare personnel’s perceived resources several years following the outbreak of SARS in Canada. Two measurement tools were utilized, an audit tool for occupational health and infection prevention resources regarding personnel, educational resources and equipment; then a questionnaire for completion by healthcare personnel to detail their perception of those resources available to them. There were discrepancies in staffing between British Columbia and Ontario hospitals (1 ICP/175 beds average with range 1 ICP/32 beds to 1 ICP/809 beds in British Columbia; 1 ICP/90 beds with range: 1 ICP/62 beds to 1 ICP/135 beds in Ontario) for \(P = 0.014\). An
important discussion regarding their findings including a discrepancy between what healthcare personnel perceive to be available to them vs. what is actually accessible within each healthcare facility, indicating an area where there is need for improved communication between experts in infection prevention, occupational health, and healthcare personnel. It seems that healthcare personnel had a false sense of security related to expertise and resources when they were not which is particularly problematical, since perception of safety is a strong determinant of safety climate and willingness to work and comply with safety measures.

Randle and Clarke (2011) conducted a qualitative study of infection control nurses’ perceptions of the Code of Hygiene. Since infection prevention has risen on the healthcare agenda in the United Kingdom over the past ten years, the researchers wanted to understand the experiences and perceptions of senior infection preventionists who held responsibility for implementing the day-to-day aspects of England’s Code of Hygiene. A small convenience sample of eight senior infection preventionists in eight English facilities were approached to participate in telephone interviews and 100% consented to participate, but only five of them were actually able to participate due to work commitments. Each subject had primary responsibility within their team and organizations for developing and ensuring compliance with the Code of Hygiene and all worked in organizations that were separate from the researchers. The sample was spread across various geographical sites throughout England, adding credibility to the findings. The local research ethics committee that the study fulfilled the criteria of service
evaluation, thus ethical approval was not sought from participants’ trusts even though principles of consent, anonymity, and confidentiality were followed. Aims of the study were described to participants on the initial telephone interview. Subjects who agreed to participate were contacted at a prearranged time and reassured they could withdraw from the study at any time. Recordings were given a numeric identifier and recordings and electronic transcripts were password protected. A semi-structured interview guide was devised and piloted within the infection prevention team at the researchers’ workplace. Themes identified in the study included interventions and barriers to compliance. Categories of interventions included external threats and authority while categories of barriers to compliance included resources and doctors. The Code of Hygiene was perceived as a potential threat of censure from outside agencies, profoundly affecting how infection prevention would be managed via senior manager intervention and assuming greater responsibility rather than being solely left to the infection preventionist. Infection preventionists now exert their authority by going directly to the chief executive with problems. Participants realized that there will always be areas for improvements in compliance, particularly in relation to necessities such as isolation rooms as well as “clinical champions”, providing the infection preventionists with much greater visibility. A study finding was evidence of an authoritarian management style that is unlikely to support infection prevention practice that can be embedded or sustained. They also identified a perception that senior managerial intervention would be considered to have potential for external censure via newsworthy infection-related stories occupying the public’s interest in infection prevention and control. The media has been critical to
increasing the public awareness of healthcare associated infections related to outbreak situations. Participants reported that full compliance was not achievable due to lack of resources and professional grouping. Specifically, they complained that doctors were the only group of staff members who were non-compliant.

In a study via retrospective chart review by Meeks et al. (2011), they attempted to identify compliance with Surgical Care Improvement Project (SCIP) guidelines for surgical site infection prevention in a subset of adult patients undergoing elective and emergent laparotomies for colorectal procedures, abdominal hysterectomies, and abdominal vascular procedures at two teaching hospitals under the same administration in Houston, Texas. 517 patients were included in the analysis: 171 from July through December 2006 and 271 from July through December 2007. Cases were comprised of 316(61%) abdominal hysterectomies, 189(37%) colorectal cases, and 14(3%) abdominal vascular cases. Of all cases, 442 were elective and overall compliance with all three antibiotic prophylaxis guidelines occurred in 62% (274/442) of the cases. There was no statistically significant difference in overall compliance with antibiotic guidelines between the two facilities. Compliance with antibiotic prophylaxis with statistical significance of \( P < .001 \) was identified in the following cases: 1) Timing of Antibiotics in Gynecology service for both all (N = 316, 88%) and elective cases only (N = 309, 89%), 2) cases occurring in 2006 both all (N = 211, 71%) and elective cases only (N = 171, 75%), 3) Emergent cases for all (N=75, 56%), 4) Weekday cases for all (N = 75, 56%), 5) Weekday cases for all (N = 492, 81%), 6) Appropriate Antibiotics in Gynecology service
for both all (N = 316, 92%) and elective cases only (N = 309, 92%), 7) cases occurring in 2006 both all (N = 211, 52%) and elective cases only (N = 171, 61%), 8) Emergent service for all (N = 75, 13%), 9) Weekday for all (N= 492, 68%), 10) Day shift for all (N = 492, 68%), 11) Discontinuation of Antibiotics in Gynecology service for all (N = 313, 96%), 12) Emergent service for all (N = 69, 71%), and 13) Day shift for all (N= 458, 92%). This study identified Gynecology Surgery as the only independent predictor of compliance for elective procedures. The researchers identified two potential explanations for this: first is that there was a major initiative several years previous to the study secondary to a high surgical site infection rate within the service, and second that cefazolin is a readily available, cost-effective single-agent utilized for prophylaxis among hysterectomy patients. Polk (2011) commented on this study, supporting a push to mandate checklists that would elevate compliance toward 100% and also encouraging national specialty associations to work toward compliance via agreed-upon performance measures comparably to gynecologists.

Douglas Scott (2009) used Consumer Price Index adjustments to publish a range of estimates for the annual direct hospital costs of treating healthcare-associated infection in the United States. Overall direct medical costs range from $28.4 to $33.8 billion for all urban consumers and $35.7 billion to $45 billion for inpatient hospital services. He adjusted for the range of effectiveness of potential infection prevention interventions, and then predicted that the benefits of infection prevention range from $5.7 to $6.8 billion for all urban consumers to a high of $25.0 to $31.5 billion for inpatient hospital services. He
proposed that even if effectiveness of infection prevention is low, the direct medical cost of preventable infection is comparable to the costs of strokes ($6.7 billion), diabetes mellitus with complications ($4.5 billion), and chronic obstructive lung disease ($4.2 billion) as calculated from Healthcare Cost and Utilization Project data (Levit, Stranges, Ryan, & Elixhauser, 2008).

Level of trauma care quickly evolved in the Iraq and Afghanistan wars. According to Atul Gawande (2004), the leaner, faster-moving military medical units add to the imperative to push surgical teams ever closer toward battle in a strategic adjustment from previous wars. Each Forward Surgical Team (FST) moves directly behind troops to establish a functioning hospital using three Deployable Rapid Assembly Shelter (“drash”) tents attached to one another forming a 900 foot facility capable of evaluating and performing surgery on ≤30 wounded soldiers plus up to six hours of postop critical care. Thus, medics/corpsmen provide battlefield level I care; the FST provides Level II; the next (Level III) is provided by a Combat Support Hospital that has 248 beds with six operating tables with radiology and laboratory facilities, plus they are also modular units shipped via air, tractor-trailer, or ship and can be fully functional in 24-48 hours, and where patients can have a maximum length of stay of three days; level IV is provided in Rota, Spain or Landstuhl, Germany, but if they are expected to require >30 days of treatment, wounded soldiers are transferred to continental United States (CONUS), mostly to Walter Reed or Brooke Army Medical Center.
Kyle Petersen et al. (2007) updated the description of war trauma-associated infections (WTAIs) of Navy/Marine war-wounded from Operation Iraqi Freedom. Briefly, they spelled out the five levels of care (Echelon 1-5) as:

- **Echelon 1**, “Buddy Care” by medics, corpsmen, PA or 1 Physician
- **Echelon 2**, Forward Resuscitative Surgical System (FRSS) by two surgeons plus support staff
- **Echelon 3**, *USNS Comfort* hospital ship with 12 operating rooms, complement of physicians with some sub-specialists and support staff
- **Echelon 4**, Fleet Hospital 8, Rota Spain, full tertiary care hospital with intensive rehabilitation or special needs, with complement of physicians with most sub-specialists, and support staff
- **Echelon 5**, National Naval Medical Center, Bethesda, Maryland, full tertiary care hospital with specialized medical care – reconstructive surgery and all subspecialty physicians, support staff including orthotics/prosthetics

By 2009 David Tribble et al. (2010) fine-tuned the Trauma Infectious Diseases Outcomes Study (TIDOS) to reflect the most current levels of military casualty care where surgical and medical interventions are performed:

- **Level I** = point of injury/first responder including self care/buddy care/medic; location in combat zone including battalion aid stations (BAS)
- **Level II** = resuscitation and surgical stabilization; medical unit types include mobile field surgical teams, and forward surgical teams; location in combat zone (IIa includes military facilities with holding capacity but no surgical assets, while
IIb includes facilities that are augmented with surgical assets including a FST or marine shock trauma platoon).

Level III = further medical/surgical care at combat support hospital (full operating room and surgical specialty care available; highest available in theater during OIF/OEF); location in combat zone.

Level IV = further medical/surgical care at fixed facility regional medical center in Europe (commonly Landstuhl regional Medical Center in Germany); location in communication zone.

Level V = definitive treatment/rehabilitation at major tertiary care center; location in United States

The DoD and VA Multicenter Cohort Study Evaluating Infection-Associated Clinical Outcomes in Hospitalized medical Evacuees following Traumatic Injury (Tribble et al., 2010) covers data on injury parameters that include type of injury (blunt or penetrating), anatomic site, early interventions, and delayed care management. Data on co-morbid illness information, infectious and non-infectious, are collected. Combat trauma cases present with a wide variety of injuries and heterogeneous medical problems during their subsequent care. To provide internal and external comparability of such a traumatized patient population, validated scoring systems will be utilized.

Independent variables will include numerous patient factors assessed in relationship with documented compliance to ASC, ISO, and CHG baths. One specific independent variable will be the Injury Severity Score (ISS), a validated scoring system. A study by Dunne, Riddle, Danko, Hayden, and Petersen (2006) identified that in combat casualty care during the seven week period of the 2003 assault phase of Operation Iraqi Freedom, 210 critically injured patients admitted to the USNS Comfort were stratified by
age, gender, and ISS. Multivariate regression analysis was used to assess blood transfusion and hematocrit as independent risk factors for infection and intensive care unit admission controlling for age, gender, and ISS. Blood transfusion was required in 44% (n = 93) of the study cohort. Transfused patients had a higher ISS (18 ± 4 vs. 10 ± 3, P < 0.01), higher pulse rate (105 ± 4 vs. 93 ± 3, P <0.0001), plus lower admission hematocrit (27 ± 1 vs. 33 ± 2, P <0.0001) compared with patients not transfused. Subjects receiving blood transfusion had an increased infection rate (69% vs. 18%, P <0.0001), ICU admission rate (52% vs. 21%, P <0.0001), and ICU length of stay (6.7 ± 2.1 days vs. 1.4 ± 0.5 days, P <0.0001) compared with patients not receiving transfusions; but there was no significant difference in mortality between patients receiving transfusions and those who did not receive transfusions. Multivariate binomial regression analysis ascertained blood transfusion and hematocrit as independent risk factors for infection (P <0.01) and blood transfusion as an independent risk factor for ICU admission (P <0.05).

The study concluded that since blood transfusion was an independent risk factor for infection and increased resource use, plus combat casualties have a high incidence of blood transfusion, consideration should be given to using alternative blood substitutes and recombinant human erythropoietin in treating and managing combat casualties.

In a study by Eastridge et al. (2006), Injury Severity Score was utilized in a retrospective study review of the Joint Theater Trauma Registry for all battlefield casualties admitted to surgical facilities during Operation Iraqi Freedom from January through July 2004. They utilized univariate and multivariate analyses to determine the
degree to which admission physiology and injury severity correlated with blood
utilization, necessity for operation, and acute mortality. The outcome variable total blood
product utilization was significantly correlated with base deficit ($r = 0.61$), admission
hematocrit ($r = 0.51$), temperature ($r = 0.47$), and ISS ($r = 0.54$). Blood pressure, GCS,
and ISS together demonstrated a significant association ($p < 0.05$) with mortality (area
under ROC curve = 95%) using multiple logistic regression techniques. Multiple linear
regression indicated that blood pressure, heart rate, temperature, hematocrit, and ISS had
a collective significant effect ($p < 0.05$) on total blood product utilization, explaining 67%
of the variance in this outcome variable. They determined that admission physiology and
injury characteristics demonstrate a strong capacity to predict resource utilization in the
modern day battlefield environment and advise that such predictive yield could have
significant implications for triage and medical logistics in a resource-constrained
environment, generalizable to mass casualties in war or civilian trauma settings.

persons due to motor vehicle accidents taken to eight different Baltimore hospitals and
that resulted in death during a two year period of 1968 to 1969. The Office of the Chief
Medical Examiner of Maryland provided a secondary data source for individuals who
died following hospital admission, those who were dead on arrival, died in emergency
rooms prior to admission, or might not have appeared in hospital admission/discharge
records. They coded the Abbreviated Injury Scale as if the outcome were not known so
that all injuries were rated by severity, irrespective of injury severity with the most severe
injury coded as “5”, not including fatal codes of “6” to “9”. Overall ratio of hospital admissions to deaths was 8:1, ranging from 5:1 to 60:1 in individual hospitals, reflecting differences in the proportion of severely injured patients each hospital received. Percentage of patients who died rose with the Abbreviated Injury Scale of the most severe injury and for that proportion who were determined to be dead on arrival. Controlling for severity of primary injury enabled the study to measure the effect of additional injuries upon mortality. They found that injuries that would not normally have been life-threatening had a marked effect on mortality when occurring in combination with other injuries. They found that the Injury Severity Score represented an important step in summarizing injury severity, particularly in patients with multiple trauma via an easily-derived score based on the widely used injury classification system of the Abbreviated Injury Scale.

Baker and O’Neill (1976) summarized major changes in the Abbreviated Injury Scale, extending its potential usefulness. The additional AIS 6 code was applied to specified injuries i.e., crushed head or transection of the torso that invariably result in death given the current emergency care capabilities, advising that an Injury Severity Score not be given to anyone with such an injury. This summary verified the original 1974 study results and extended the potential usefulness of the Injury Severity Score.

Abbreviated Injury Scale (AIS) and Injury Severity Score (ISS) were reviewed by Linn (1995), who assessed it as an excellent method for retrospective comparison of overall injury data between populations differing in time or space. The Abbreviated
Injury Scale is used for both blunt and penetrating injuries, and has been used to analyze data in various populations in various Western countries including Canada, England, Germany, Japan, France, and Australia (MacKenzie, Shapiro, & Eastham, 1985). While other more complicated indices of severity that include both anatomic and physiologic data may have questionable utility due to inter-rater and intra-rater variability, Linn reported that the usefulness and advantage of the ISS in retrospective studies are its relative simplicity and its widespread use, enabling comparison to findings in other studies.

The Sequential Organ Failure Assessment (SOFA) is used to assess the general health of subjects enrolled in this study on an interval basis to permit comparisons within the cohort and the general study population. It is a scoring system measuring clinical and physiologic functions that are major determinants of mortality (Tribble et al., 2010). According to Vincent et al. (1996), SOFA scores are derived from six organ systems graded from 0 to 4 according to the degree of dysfunction/failure to “... describe a sequence of complications in the critically ill.” Rather than competing with existing severity indices, SOFA scores complement them. Because severity indices don’t allow evaluation of individual function of each organ separately, the SOFA uses a score from 0 equal to normal to 4 equal to most abnormal for each of six organs (respiration, coagulation, liver, cardiovascular, central nervous system, and renal). Mortality rate is directly related to the degree of organ dysfunction, so it is also related to the SOFA score for each organ system.
The SOFA score is a reliable indicator of prolonged length of stay and death in trauma patients (Antonelli et al., 1999), and was used to assess general health of enrolled subjects on interval basis plus permit comparisons within the cohort and the general study population via a standardized approach. It is considered a tool that describes organ dysfunction and severity of dysfunction of each organ, and not just a global number giving no information on individual organ status. Specifically the SOFA score can describe organ failure in trauma patients and may be useful for assessing the evolution of organ failure over time. For those patients who died, they had a higher total SOFA score and the majority of them died within the first 10 days. Antonelli et al. (1999) found in their study of 140 males and 41 females that non-survivors were significantly older than survivors (51 years ± 20 vs. 38 ± 16 years, p < 0.05) and had higher global SOFA admission score (8 ± 4 vs. 4 ± 3, p <0.05) and throughout their 10 consecutive days. Several scores were consistently higher upon admission for the non-survivors including respiratory (>3 in 47% of non-survivors vs. 17% of survivors), cardiovascular (>3 in 24% of non-survivors vs. 5.7% of survivors), and neurological systems (>4 in 41% of non-survivors vs. 16% of survivors); and although the trend continued throughout the study, the first four to five days demonstrated more acute differences. Additionally, when analyzed daily over 10 consecutive days, the SOFA score also showed a persistent trend with values always higher in non-survivors than in survivors. While the respiratory score seemed to distinguish between survivors and non-survivors better than other components, non-survivors also had more severe scores for cardiovascular and neurological systems.
Ferreira, Bota, Bross, Mélot, and Vincent (2001) studied SOFA scores of 352 consecutive patients admitted to a 31-bed medical/surgical intensive care unit for >24 hours in Belgium. They found that initial, highest, and mean SOFA scores correlated well with mortality, with initial and highest scores of >11 or mean scores of >5 corresponding to mortality of >80%. Predictive value of the mean score was independent of the total length of stay in the intensive care unit. Mean and highest SOFA scores had the strongest correlation with mortality in univariate analysis, followed by Δ-SOFA scores (differences between subsequent SOFA scores), and initial SOFA scores. The area under the receiver operating characteristic curve was largest for the highest scores (0.90; SE, 0.02; \( P < .001 \) vs. initial score). During the first 96 hours following admission, when analyzing trends in the SOFA score, the mortality rate was at least 50% when the score increased, 27%-35% when it remained unchanged, and <27% when it decreased. Prediction of differences in mortality within the first 48 hours was better than in the subsequent 48 hours; and there was no significant difference in the length of stay among these groups. Except for patients with initial scores of >11 (mortality rate >90%), a decreasing score during the first 48 hours was associated with a <6% mortality rate while an unchanged/increasing score was associated with 37% mortality rate when the initial score was 2-7 and 60% when the initial score was 8-11. Thus, per Ferreira et al. (2001), sequential assessment of organ dysfunction during the early days of an intensive care unit admission is a good indicator of prognosis, plus both mean and highest SOFA scores are particularly valuable predictors of outcomes.
Gm (-) MDR infection: standardized definitions for colonization and nosocomial infections are used as defined by the CDC’s National Healthcare Safety Network (NHSN) in order to permit comparisons within and between hospitals and also to be able to assess temporal trends in an aggregated database (Horan, Andrus, & Dudeck, 2008).

In the Trauma Infectious Diseases Outcomes Study (TIDOS) (Tribble et al., the NHSN standardized definitions are utilized for infection-related-parameters. While not all infections occurring in military trauma patients are expected to be nosocomial, a large proportion of them are expected to be. In an attempt to approach standardized case definitions there are some modifications to improve specificity by leveraging the detailed clinical and microbiological assessment. Information used to determine the presence and classification of infection should be a combination of clinical findings and results of laboratory and other tests. Patients’ providers will provide documentation of clinical evidence from direct observation of the infection site that will be extracted by study personnel through review of pertinent sources of data i.e., patient’s chart, laboratory test reports, or reports from other diagnostic studies i.e., x-ray, ultrasound, computed tomography (CT) scan, magnetic resonance imaging (MRI), radiolabel scan, endoscopic procedure, biopsy, or needle aspiration. Also, a physician’s diagnosis of infection can be derived from direct observation during a surgical intervention, endoscopic exam, or other diagnostic studies or clinical judgment is an acceptable criterion for an infection unless there is compelling evidence to the contrary. An example of refutable evidence would be that information was written in the wrong patient’s record or that the presumptive diagnosis was not further substantiated by subsequent studies. There are times when a
physician’s clinical diagnosis in the absence of supportive data must be supplemented by the initiation of appropriate antimicrobial therapy to satisfy the criterion.

Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) have been ongoing since the US invasion of Iraq in 2003. OIF had 49 casualties with 61 wounded undergoing culture near times of injury, revealing a predominance of gram-positive bacteria with some methicillin resistant *Staphylococcus aureus* (MRSA), but no gram-negative bacteria such as *Pseudomonas aeruginosa* or *Acinetobacter baumannii-calcoaceticus* complex (ABC) (Murray et al., 2006). Yun et al. (2006) assessed cultures from Baghdad’s Combat Support Hospital (CSH), identifying non-U.S. personnel with a higher proportion of *Pseudomonas aeruginosa*, *Klebsiella pneumonia*, and ABC. Scott, et al. (2007) reported healthcare-associated transmission of pathogens in the operating rooms in the CSH with bacteria identified in soldiers upon their return to the U.S. Additional concerns are related to likely transmission of infections within military hospitals to people who were not deployed overseas.

With war-wounded casualties’ survival and reaching definitive medical care, infection prevention and control takes on new significance in battlefield trauma care. According to Aranson, Sanders, and Moran (2006), as *Acinetobacter baumannii-calcoaceticus* complex (ABC) pathogens were being determined among Operation Iraqi and Operation Enduring Freedom (OIF/OEF) casualties, other virulent pathogens classically associated with battlefield trauma including *Pseudomonas aeruginosa*, *Stenotrophomonas*, *Klebsiella pneumoniae*, and *Staphylococcus aureus* were also being seen. They identified that the multidrug resistant patterns of methicillin-resistant *S.*
aureus (MRSA), extended spectrum β-lactamase (ESBL) producing K. pneumoniae, and multidrug resistant P. aeruginosa were of greater concern.

All participating laboratories follow Clinical and Laboratory Standards Institute (CLSI) standards. Multidrug resistance among gram negative bacteria was defined as resistance or intermediate susceptibility to at least three of the following antimicrobials or antimicrobial groups: 1) ampicillin-sulbactam or piperacillin-tazobactam, 2) meropenem, 3) ceftazidime or ceftriaxone, 4) ciprofloxacin, and 5) gentamicin, using breakpoint values defined by the Clinical and Laboratory Standards Institute (Performance standards for antimicrobial disk susceptibility tests. Wayne, PA: Clinical and Laboratory Standards Institute; 2006. Approved Standard: M2-A9.).

Horan et al., (2008) published updated definitions of healthcare-associated infection (HAI) with criteria for specific types of infection in acute care settings. These criteria enable comparison of data throughout healthcare as long as the definitions for both infection and device utilization are followed. For purposes of surveillance for HAI, there must be no evidence that the infection was present or incubating at the time of admission to the acute care setting.

Beginning in 2004 the CDC updated the guidelines for preventing HAI pneumonia. In 2006 and 2007, Siegel et al. and CDC’s Healthcare Infection Control Practices Advisory Committee (HICPAC) published both new guidelines related to healthcare-related MDRO infection and updated guidelines for preventing HAIs in hospitals.
Between 1997 and 2008 the CDC collaborated with Rollins School of Public Health, Emory University, on antimicrobial resistance in intensive care units (ICUs) of CDC’s National Nosocomial Infection Surveillance (NNIS) participating hospitals. McGowan et al. (2002) identified that more frequent statistically significant associations were found among resistance rates for gram-negative organisms than gram-positive ones and that resistance to third generation cephalosporins in *Klebsiella pneumoniae* (CF3R-KP) was significantly correlated with the majority of other sentinel antimicrobial-resistant organisms: CF3R-Enterobacter species 0.52 ($P = .0007$), CF3R-*Pseudomonas aeruginosa* 0.54 ($P = .0004$), fluoroquinolone resistant (FQR)-*Escherichia coli* 0.43 ($P = .0057$), and imipenem resistant (IMR)-*Pseudomonas aeruginosa* 0.35 ($P = .0309$). A high prevalence of that organism may serve as a marker for more generalized resistance problems in hospital inpatient areas.

In 2008 Kollef et al. published findings of the Healthcare Care-Associated Pneumonia (HCAP) Summit in which they documented a new designation for healthcare-associated pneumonia, covering pneumonias acquired in healthcare environments outside of the traditional hospital setting and excluding hospital-acquired pneumonia (HAP), VAP, and community-acquired pneumonia (CAP). They determined that patients with HCAP are at high risk for MDR Gm (-) infection, and that in some scenarios no single antibiotic will cover greater than 80%-85% of strains. Therefore they suggest that empirical use of combination therapy could be effective to ensure microbiologically adequate treatment. They advised that for future directions, the consequences of
inadequate antibiotic therapy for patients with severe HCAP requiring ICU admissions are likely to be greater than for those requiring a general admission, nursing, or other setting outside of a hospital.

MacDougall and Polk (2005) discuss antimicrobial stewardship programs in relation to computer-assisted strategies enabling physician order-entry systems in hospitals. Those encounters can be designed to facilitate each of the antimicrobial stewardship strategies related to patient evaluation, choice of antimicrobial for prescribing, prescription ordering, dispensing of antimicrobial as well as feedback and reporting capabilities. They describe enhanced understanding of the relationship between antimicrobial use and resistance, develop and spread of computerized order-entry & decision support systems, antimicrobial use surveillance and benchmarking locally/nationally. Antimicrobial resistance is first and foremost a local problem with selection for and amplification of resistant members of a species occurring in individual hospitals/communities that then spread worldwide. Most published studies report antimicrobial stewardship programs at least cover their costs and may provide significant cost savings through reduction in drug costs, providing financial incentive to bottom-line-wary administrators.

In 2008 DiazGranados, Cardo, and McGowan published a review of antimicrobial resistance to include international control strategies with a focus on limited-resource settings. The authors considered strategies for minimizing resistance necessary at different levels of responsibility, ranging from the individual patient care provider to
international agencies. It gave responses potentially appropriate according to the
resources available for control, focusing on limited-resource settings. They concluded
that medical and public health agencies must be in the forefront of such efforts.

Dong, Yan & Wang (2008) described antibiotic prescribing patterns in village
health clinics in China. They collected approximately 20,125 prescriptions from 680
primary health clinics in villages of 40 counties in 10 provinces in Western China.
Percentage of prescriptions with antibiotics and the number of antibiotics per 100
prescriptions were used as measurements of antibiotic utilization. 48.43% of prescriptions
were for antibiotics (range: 41.12-57.47). In all there were 49 different kinds of
antibiotics prescribed and 17 of them accounted for 90% of all usage. Number of
antibiotics/100 prescriptions was 54.62 (range: 43.78-69.56). Frequency and proportion
of prescribed antibiotics in these rural areas are higher compared with developed
countries and the patterns of antibiotic prescription differ greatly among provinces.

Petersen et al. (2007) identified that invading Iraq led to casualties from high-
velocity gunshot, shrapnel and blunt trauma injuries and burns. The researchers
conducted retrospective record reviews of all trauma casualties of people 5-65 years old
evacuated from Iraqi theater to USNS Comfort between March and May 2003. Using
positive wound, sterile body fluid, and at least two infection-associated signs/symptoms
as diagnosis criteria, the researchers identified 56 of 211 patients as meeting the criteria
for infection. Infections were more common in blast injuries, soft tissue injuries, patients
with greater than three wound sites, loss of limb, abdominal trauma, and higher Injury
Severity Score (ISS). They found that 84% of infections were secondary to wounds, 38% were due to bloodstream infection. 36% were due to the predominant organism *Acinetobacter* species, followed by *Escherichia coli* and *Pseudomonas* species at 14% each. Gm (-) rods, particularly *Acinetobacter* species, accounted for the majority of wound infections cared for on *USNS Comfort* during Operation Iraqi Freedom (OIF). MDR was common with the exception of carbapenem class, limiting antibiotic therapy options.

Murray et al. (2009b) described a three-year war-related period 2005-2007. During that time there were 2,242 Operation Iraqi Freedom/Operation Enduring Freedom (OIF/OEF) admissions (560 in 2005, 724 in 2006, and 958 in 2007). The most commonly recovered pathogens on admission screening cultures were methicillin-resistant *Staphylococcus aureus* (MRSA), *Klebsiella pneumoniae* and *Acinetobacter*. Annual nosocomial infection rate of those pathogens ranged from 2% to 4% with remarkable changes in resistance profiles for *Acinetobacter*, *K. pneumoniae*, and *S. aureus* over time. The percentage of military patients with MRSA on admission was stable, but ESBL-producing *K. pneumonia* increased slightly (not statistically significant). *Acinetobacter* was present in 72 OIF/OEF patients in 2005 (52 peri-admission time), 83 in 2006 (58 peri-admission), and 77 in 2007 (60 peri-admission). While the U.S. military monthly Iraqi casualty rate correlated with the U.S. monthly mortality rate (\( R = 0.676, P < 0.01 \)), Brooke Army Medical Center (BAMC) OIF/OEF admissions did not. Among OIF/OEF admissions, there was possible, although weak correlation between U.S. monthly casualty rate and rate of ESBL-producing *K.*
*pneumoniae* colonized ($R = 0.415, P = 0.01$). The lone possible correlation between U.S. deaths and MDR pathogen was for the colonization rate with ESBL-producing *K. pneumoniae* ($R = 0.506, P < 0.01$). BAMC admissions did not correlate with colonization rates of any of the pathogens. Study period colonization rates showed notable spikes for ABC, ESBL-producing *K. pneumoniae*, and MRSA that didn’t seem to be associated with year, seasonality (colder/warmer months or wet/dry seasons in Iraq), or calendar month. Monthly recovery of *Acinetobacter baumannii* in OIF/OEF patients at time of admission ranged from 18% to 0% and ESBL-producing *K. pneumoniae* from 10% to 0%, both showing a decreased rate in 2007 even though there was an overall increase in number of OIF/OEF admissions; however, numbers were too small to draw any statistical significance. There were remarkable changes in antimicrobial resistance profiles 2005-2007 in comparison to data before 2004-2005, but some resistance data were not available due to lack of adequate numbers of pathogens to generate an antibiogram for the facility. While ABC colonization was the most commonly recovered MDR pathogen of interest, the rate of patients arriving with it decreased each of the last three years. Murray et al. (2009b) identified that infection prevention procedures seemed to have impact upon further nosocomial transmission of bacteria, consistent with prior studies showing that the most effective method in reduction of rates of nosocomial infection was the implementation of active surveillance. OIF/OEF casualties with prolonged hospital courses with frequent movement within the facility due to rehabilitation may increase their exposure risks as they frequent the same areas of the hospital. In this period of time, ABC isolates became more resistant than isolates recovered from inpatients or outpatients.
who were not deployed. In keeping with the concerns of the Murray et al. study, the lack of new Gm (-) antimicrobial agents had been cited as a concern to the Infectious Diseases Society of America in their public policy statement (Spellberg et al., 2008). They also supported funding to support monitoring, tracking, and prevention/control plans over antibiotic resistant infections.

CDC (2004a) published a report of 102 wounded U.S. service members in Iraq, Kuwait, and Afghanistan developing Acinetobacter baumannii colonization and infection between January 1, 2002 and August 31, 2004. Antimicrobial susceptibility testing (AST) was performed via micro-dilution. Results showed 33 Acinetobacter baumannii isolates from LRMC, 45 isolates from WRAMC. Three other medical treatment facilities identifying Acinetobacter baumannii bloodstream infections in injured service members include U.S. Navy hospital ship USNS Comfort (11 patients), National Naval Medical Center, Bethesda, Maryland (8 patients), and Brooke Army Medical Center, San Antonio, Texas (5 patients).

Borer et al. (2007) did a prospective cohort trial of 4% chlorhexidine gluconate baths in a medical intensive care unit (MICU) with a high endemic rate of Acinetobacter baumannii. Their prevalence of Acinetobacter baumannii skin colonization upon admission to the MICU initially was 55 of 320 (17%) patients before the intervention. Disinfection via daily bathing was done until discharge of colonization status. Prevalence of remaining MICU patients at 24 hours was 5.5% and at 48 hours was 1% following the disinfection regimen \( P = 0.002, \text{OR: 2.4} \). Following a second screening, 80% of
colonized patients were decolonized. Prevalence of *Acinetobacter baumannii* bloodstream infections decreased from 4.6 to 0.6 per 100 patients (*P* \(\leq 0.001; \) OR: 7.6) and incidence decreased from 7.8 to 1.25 (85% reduction). They concluded that decolonization bathing with 4% chlorhexidine gluconate solution should be considered in addition to other well-known infection prevention measures, particularly in facilities with endemic rates of multidrug resistant *Acinetobacter baumannii*.

The MDRO IOM report (Choffnes et al., 2010) described that infection control is expensive and becomes more difficult and less effective whenever patients come into a hospital already carrying a resistant pathogen. In response to a 1996 region-wide vancomycin-resistant enterococcus (VRE) outbreak in Iowa, Nebraska, and South Dakota, Ostrowsky et al. (2001) described a task force instituted to assess VRE prevalence throughout the facilities and implement recommendations for screening, infection control, and education at 32 healthcare facilities throughout the region. Active surveillance cultures were initiated and obtained from 1,954 of 2,196 eligible patients (89%) in 1998 and 1,820 of 2,049 eligible patients (89%) in 1999. The overall prevalence at 30 facilities that participated in all three years of the study decreased from 2.2% in 1997 to 1.4% in 1998 and to 0.5% in 1999 (*P* < 0.001 by chi-square test for trend). They found that in both acute care and long-term care, the risk factors for colonization were prior hospitalization and treatment with antimicrobial agents. Active surveillance in long term care facilities was adopted by 26 of 28 (93%) in 1998. Additionally, 23 of 25 (92%) had infection control policies in 22 of 25 facilities (88%) to prevent transmission of VRE in 1999. 100% of the four acute care facilities had active screening and infection control
policies related to MDRO in 1998 and 1999. Thus, they concluded that obtaining surveillance cultures and isolating infected patients can reduce or eliminate the transmission of regional VRE MDRO in healthcare facilities.

Based on their review of the role of health care facilities as reservoirs for resistant pathogens, the IOM report (Choffnes et al., 2010, pp. 198-199) concluded that hospital infection and resistance surveillance systems should be more comprehensive, separate from The Joint Commission and other accreditations groups, and should collect data on inputs i.e. antibiotic use, number of infection preventionists, and physical inputs for hospital infection control. This would alleviate incentive problems with reporting outcomes, independent monitoring, and infection reporting complemented via infection control inputs. It reported that research should address policy-relevant questions such as ownership structure (government, for-profit, nonprofit teaching, and nonprofit nonacademic hospitals) and proximity to other healthcare facilities that might influence or predict resistance. Currently, little is known about the costs of surveillance and infection prevention activities for a typical hospital or how they compare with other hospital expenses.

Murray et al. (2009a) studied combat-related injuries in Iraq and Afghanistan via the Joint Theater Trauma Registry (JTTR) database regarding injury-specific medical data using International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) coding in two phases, before and after the end of the major ground operations in Iraq. They identified that 1109 patients were evaluated before and after the end of major ground operations in Iraq, finding that approximately one-third of them had
infectious complications. The most common anatomic or clinical syndrome codes were skin or wound followed by lung, and the most common pathogen code was Gm (-) bacteria. Site of injury had varying rates of infectious complications (IC): spine/back 53%, head/neck 44%, torso 43%, and extremity 35%. ISS and certain mechanisms of injury (explosive device, bomb, and landmine) were associated with infectious complications on multivariate analysis ($P < 0.01$). They recommended that improved data capture and more specific clinical information is required to improve overall combat-related injury infection care.

A research team investigated a newly opened level II US military hospital in the Wasit Province of Iraq (Ake et al., 2011) for development of nosocomial flora and healthcare personnel colonization/infection with gram negative MDROs near the beginning of the casualty evacuation chain. Swab sampling (wounds, axilla, groin, groin/axilla) of patients, hospital personnel, and environmental surfaces was performed pre opening and then serially over the next six months. Multidrug resistant isolates were genotypically characterized using pulsed-field gel electrophoresis (PFGE), then univariate and multivariate analysis were performed to evaluate associations between patient characteristics and MDRO carriage. The study collected a total of 1,348 samples, yielding 654 isolates, 42 of which were MDROs. 158 patients were sampled; swabs from 18 patients yielded 29 MDR isolates. Host nation patients comprised 89% of patients with MDROs plus 37% of patients without MDROs ($P < .001$). Host nation patient status was significantly associated with MDRO carriage in multivariate logistic regression analysis (adjusted odds ratio, 2.9; CI, 1.3-6.3; $P = .009$). PFGE patterns of bacteria from
those recovered from host nation patients matched those that were later isolated from environmental surfaces including recovery room patient monitors and the trauma bay floor. They concluded that MDRO isolation in this facility was predominantly obtained from newly admitted host nation patients that may reflect baseline colonization with MDROs in the community. Patient MDRO carriage was linked to later environmental contamination, supporting intensive infection control efforts in forward deployed facilities.

Vincent et al. (1996) explained Sequential Organ Failure Assessment (SOFA) on behalf of the Working Group on Sepsis-Related Problems of the European Society of Intensive Care Medicine, a consensus meeting of experts in 1994 that created the scoring system. In 2001 Ferreira et al. described the Sequential Organ Failure Assessment (SOFA) score. The goal was to determine the usefulness of repeated SOFA measurement for prediction of mortality in ICU patients. It was a prospective observational cohort study from April 1-July 31, 1999. 352 consecutive patients (mean age, 59 years) were admitted into a 31-bed medical/surgical ICU at a university hospital in Belgium for >24 hours for whom the SOFA score was calculated on admission and every 48 hours until discharge. Main outcome measures included the initial SOFA score (0-24), and changes of SOFA scores. Initial, highest, and mean SOFA scores correlated with mortality. Initial and highest scores of >11 or mean scores of >5 corresponded to mortality of >80%. Predictive value of the mean score was independent of the length of ICU stay. In univariate analysis, mean and highest SOFA scores had the strongest correlation with
mortality, followed by Δ-SOFA and initial SOFA scores. The area under the receiver operating characteristic curve was largest for highest scores (9.90; SE, 9.02; \( P < .001 \) vs. initial score). When analyzing trends in the SOFA score during the first 96 hours, regardless of the initial score, the mortality rate was at least 50% when the score increased, 27% to 35% when it remained unchanged, and <27% when it decreased. Differences in mortality were better predicted in the first 48 hours than in the subsequent 48 hours. There was no significant difference in the length of stay among these groups. Except for initial scores of >11 (mortality rate >90%), a decreasing score during the first 48 hours was associated with a mortality rate of <6%, while an unchanged or increasing score was associated with a mortality rate of 37% when the initial score was 2-7 and 60% when the initial score was 8-11. Sequential assessment of organ dysfunction during the first few days of ICU admission was determined to be a good indicator of prognosis. Both the mean and highest SOFA scores were particularly useful predictors of outcome. Independent of the initial score, an increase in SOFA score during the first 48 hours in the ICU predicted a mortality rate of \( \geq 50\% \). The proposed research study will see if there is an association between SOFA scores, MDRO infections, and compliance with infection prevention protocols.

Martin and English (2010) testified before the House Armed Services Committee regarding Navy Medicine’s management of MDRO infections in war-wounded. They reported changes in practice i.e., cohorting of coalition patients away from U.S. military war-wounded to lessen likelihood of healthcare-associated transmission of MDRO
pathogens from coalition patients. Standard infection prevention procedures were re-emphasized at all levels of care as were first established at the National Naval Medical Center (NNMC) in Bethesda, Maryland in 2003. That was the time when they initiated empiric Contact Precautions and active surveillance cultures for *Acinetobacter* following an outbreak of *Acinetobacter* on the *USNS Comfort* in the Persian Gulf due to transmission from Iraqi patients onboard, transmitted to war-wounded U.S. Navy personnel who would eventually be transferred back to NNMC. Results from that screening were collated, reviewed, and reported by monthly rates to be discussed by the Infection Prevention and Control Committee. Testimony included that further characterization of MDRO bacteria responsible for infections is performed via the capacity of Trauma Infectious Disease Outcome Study (TIDOS) and the MDRO Repository and Surveillance Network (MRSN) system of the Walter Reed Army Institute of Research (WRAIR), complementary of one another plus allowing for resistance phenotypes and molecular analysis of infecting and colonizing strains to determine relationships & common sources of such infections. TIDOS was carefully designed to combine surveillance, laboratory and clinical data of combat-injured patients identified via Department of Defense (DoD) medical treatment facilities, following them through their transition to the Veterans Administration (VA) system. TIDOS has identified that 40% of their cohort has left active duty service, registering for care in the VA Medical Center system. 60% of patients experienced at least one infection and 22% developed at least one additional infection post-hospitalization. Overall incidence rate for infection through hospitalization was 2.0 per 100 person-days. Of those patients with infections,
50% had ≥2 separate infections and 10% experienced ≥4 separate infections. The most frequent infection sites were wounds (34.6%), bloodstream infections (17.3%), and osteomyelitis/bone infection (16.5%).

CDC’s Division of Healthcare Quality Promotion (DHQP) published an equation to calculate a standardized infection ratio (SIR) for central line-associated bloodstream infection (CLABSI) and surgical site infection (SSI) data (CDC DHQP, 2010). The SSI SIR resulted from logistic regression modeling that considered all procedure-level data collected by National Healthcare Safety Network (NHSN) facilities in order to provide better risk adjustment than afforded by the previously limited risk index. Previously, all that was available for comparison was the basic SSI Risk Index based on presence of three major risk factors: 1) operation lasting >duration cut point hours, where the duration cut point is the approximate 75th percentile of the duration of surgery in minutes for the operative procedure, 2) contaminated (Class 3) or Dirty/infected (Class 4) wound class, and 3) ASA classification of 3, 4, or 5. Each patient’s SSI risk category is the number of these factors present at the time of the operation. The SSI SIR will enable military treatment facilities (MTFs), service (Navy, Army, and Air Force), DoD, and civilian hospitals to provide better risk adjustment than the SSI Risk Index.

In the HICPAC guidelines related to management of multidrug-resistant organisms in healthcare settings, Siegel et al. (2006, pp. 19-21) recommended that active surveillance cultures (ASCs) be performed upon admission, and then periodically during patients’ hospitalization in order to detect potential silent transmission. Although there is
less literature on control of multidrug-resistant Gram-negative bacilli outbreaks than Gram-positive, Siegel and colleagues indicated that active surveillance cultures have been utilized to successfully control such outbreaks. The guidelines advise on the wisdom of discontinuing Contact Precautions when \( \geq 3 \) surveillance cultures for the target MDRO are repeatedly negative over the course of a week or two in a patient who has not received antimicrobial therapy for several weeks. This is particularly recommended when the patient is asymptomatic for infection and there is no evidence of ongoing transmission from a particular patient. Decolonization for MDR GNB is an unresolved issue and there is no recommendation for decolonization because regimens and decolonization protocols for MDR GNB have not been established.

Siegel et al. (2007, pp. 43-44) point out the critical role of clinical microbiology laboratory support of infection prevention/control. It contributes to the prevention of infectious disease transmission by prompt detection and reporting of epidemiologically important pathogens, identifying emerging patterns of antimicrobial resistance, and assisting in assessment of the effectiveness of recommended precautions to limit transmission during outbreaks that may be first recognized by laboratorians. A key function is the performance of surveillance cultures as appropriate (including retention of isolates for analysis) to assess patterns of infection transmission and effectiveness of infection prevention interventions within a facility or organization. Microbiologists should be part of the multidisciplinary team making decisions regarding initiation and
discontinuation of active surveillance programs and optimization of laboratory resources usage.

The C.D.C. (2004b) published guidelines for prevention of healthcare-associated pneumonia that included donning of a surgical mask and eye protection or face shield whenever performing procedures or patient care activities that might generate sprays of respiratory secretions from any patient whether the patient has confirmed or suspected viral respiratory tract infection or not. This is a category IB recommendation that is strongly recommended for implementation and supported by certain clinical or epidemiologic studies and by strong theoretical rationale.

Aronson, Sanders, & Moran (2006) reviewed deployment-associated infections including gastroenteritis; respiratory infection; war wound infections with Gm (-) MDR bacteria; Q fever; brucellosis; and parasite infections, such as malaria and leishmaniasis. They found that combat injuries are the most dramatic health risk of war. Although public health and preventive measures have minimized the incidence of many illnesses for soldiers/marines, further prevention of vector- and foodborne infections may provide additional protection.

Hospenthal et al. (2008) published guidelines for prevention of infection following combat-related injuries. These guidelines included: 1) early wound cleansing, 2) surgical debridement, 3) antibiotics, 4) bone fracture stabilization, and 5) maintenance of infection control measures. After their survey of military treatment facilities (MTFs) in
Iraq and Afghanistan, Hospenthal and Crouch (2009) published infection control challenges in deployed MTFs. Results of their review of Level III facilities capable of holding patients >72 hours and the evacuation system from Iraq to continental U.S. were reviewed by an expert infection control-infectious disease team. They found that infection control programs were staffed by personnel with limited infection control experience, many times without perceived adequate time dedicated to perform their duties, and without uniform levels of command emphasis or support. Hand hygiene between patients was not continuously ideal, isolation/cohorting of patients to decrease MDRO colonization/infection varied among facilities, and a review of standard operating procedures identified variability among institutions and in quality of their documents. Application of theater-specific and antimicrobial control-specific measures varied among facilities. Those could partly explain the high rate of MDROs among injured service personnel. They concluded that standardization of infection control practices i.e. hand hygiene and transmission-based precautions should be in place and maintained throughout the deployed setting.

Weintrob et al. (2010) published a prospective, longitudinal cohort study at WRAMC of inpatients medically evacuated from Iraq or Afghanistan or nondeployed subjects admitted to the same hospital. Consenting patients allowed surveillance cultures every three days from six sites for two weeks and then weekly. Gm (-) organisms resistant to ≥3 classes of antibiotics were considered multidrug resistant organisms (MDROs). Isolates were genotyped via pulsed-field gel electrophoresis (PFGE). Clinical
data, data on antibiotic use, and clinical culture results were collected and will apply to the current study, too. Of 60 participants, 14 (23%) were colonized with an MDRO at admission, and 13 (22%) had an incident of colonization during hospitalization. Groin was the most sensitive anatomic site for detecting MDRO colonization and all but one subject remained colonized for the duration of their hospitalization. 60% of subjects with incident of *Acinetobacter baumannii* colonization and 25% of subjects with incident *Klebsiella* colonization had strains related to those isolated from other subjects. Of 60 non-deployed subjects, 5 (8%) were colonized with an MDRO at admission. All had recent healthcare contact and one non-deployed subject had an isolate related to a strain recovered from a deployed subject. Gm (-) MDRO colonization is common among patients with war-related trauma admitted to this military hospital and also occurs among non-deployed patients with recent healthcare contact. Groin is the most sensitive anatomic site for active surveillance and spontaneous decolonization is rare. This finding led to the refinement of active surveillance (ASC) guidance for medical treatment facilities (MTFs) receiving combat casualties resulting in standardization across MTFs.

In 2010 Hospenthal et al. further described efforts to increase awareness and enhance infection control in deployed MTFs by educating leaders and deploying personnel, producing deployed infection control resources, and standardizing level IV and V admission screening for MDRO colonization. Enhancement of infection control expertise was added via increased standardization of infection control practice, establishment of a pre-deployment infection control short course, a tele-consultation
service, and dedicated Internet resources. The standardization of admission colonization extended beyond *Acinetobacter* to MDR Gm (-) rod screening of war-wounded evacuated from Iraq via Landstuhl Regional Medical Center (LRMC) into major military health centers in continental U.S. (CONUS). This better defined and responded to the MDRO problem, informed by the Weintrob et al. study. These innovative approaches helped to enhance expertise and practice related to the reduction of MDRO infections.

A Dutch study (Willemsen et al., 2011) was initiated in response to their perception of dangers of highly resistant gram-negative rods in hospitals as a worldwide problem. They looked at variations in the incidence and contributions of clonal spread in several Dutch hospitals as well as studied the roles of antimicrobial agents, hospital characteristics, and variations in infection control policies. While they found zero clusters in six hospitals in their study, they identified multiple clusters of highly resistant gram negative microorganisms via molecular typing in seven other hospitals in their study (2 clusters in 3 hospitals, 3 clusters in 1 hospital, 7 clusters in 3 hospitals, 8 clusters in 3 hospitals, 9 clusters in 1 hospital, and 11 clusters in 1 hospital). Range of patients within a cluster was 2 to 11 (mode = 2).

Whitman et al. (2008) reported the first case of occupational transmission of HAI due to *Acinetobacter baumannii* from a U.S. serviceman wounded in Iraq. This first published report occurred in an ICU nurse within 48 hours of caring for an incoming U.S. Marine, most likely transmitted via suctioning his endotracheal tube without donning a mask or face protection. A ‘look-back’ analysis of the MDR *Acinetobacter baumannii*
from the HCW and the patient were indistinguishable via pulsed-field gel electrophoresis (PFGE). Additionally, PCR/electrospray ionization mass spectrometry indicated that the isolates were similar to strains of *A. baumannii* derived from Walter Reed Army Medical Center strain type 11. Authors determined that further studies are needed to investigate whether droplet precautions should be in place for patients with *A. baumannii* in their sputum or whether more frequent attention should be paid to ventilator maintenance and management.

Murray and Hospenthal (2005) reviewed *Acinetobacter* spp. as a challenge to physicians as one of the more problematic pathogens groups for management today. These are Gm (-) non-fermentative, non-spore forming, strictly aerobic, oxidase-negative coco-bacillary organisms that have at least 21 different strains. This summary of literature includes *Acinetobacter baumannii-calcoaceticus* complex (ABC), and in all they comprise about 80% of infections in healthcare. This pathogen can be isolated from skin, throat and other sites of healthy people and has been detected on hospital equipment including humidifiers, mattresses, and ventilators with prolonged viability periods. Infection sites include lung, urinary tract, blood, meninges, and peritoneum. It is reported to cause 1.6% of nosocomial ICU BSIs and is frequently detected after prolonged hospitalizations. A primary goal of ABC complex management is to prevent initial colonization and subsequent infection by adequate infection control. Prompt and adequate therapy with agents with in-vitro activity is required once it is established that
the bacteria represents infection and not colonization. Aggressive infection control policies should be enforced whenever *Acinetobacter* is identified.

The International Infection Control Council (Calley, Friedman, Jeanes, Piaskowski, & Scott, 2006) developed best infection control practices for patients with extended spectrum β-lactamase (ESBL) pathogens. They address patient isolation, active surveillance cultures, potential skin decontamination (cleansing and antisepsis), and equipment/environmental decontamination and disinfection. They reported that contact precautions are appropriate for patients colonized or infected with ESBLs, discontinuation of isolation following three consecutive negative samples taken a week apart, consideration of active surveillance cultures of targeted populations at high risk as well as all admissions to high risk units (ICUs, Hem/Onc, Transplant, and long term care), screening of healthcare workers only if there is epidemiological evidence of transmission from a suspected common source, no successful decolonization therapy has been identified and may lead to further microbial resistance, and published literature demonstrates rare transmission of ESBL-producing microorganisms from a common source.

Murray et al. (2006) studied bacteriology of war wound contamination at the time of injury and during therapy. In spring of 2004 U.S. military casualties presenting to 31st Combat Support Hospital in Baghdad, Iraq with acute traumatic injuries resulted in open wounds undergoing aerobic culture to identify bacteria colonizing the wounds. 49 casualties with 61 separate wounds were evaluated. They were located predominantly in
the upper and lower extremities and primarily from improvised explosive devices (IEDs) or mortars. 30 wounds (49%) had bacteria recovered on culture with 40 bacteria identified. 18 casualties (20 wounds) had undergone field medical therapy (irrigation &/or antimicrobial treatment); six of these had nine bacterial isolates on culture. Of the 41 wounds from 31 patients with no previous therapy, 24 grew 31 bacteria. Gm (+) bacteria (95%), mostly skin-commensal bacteria, were the predominant organisms identified. Three Gm (-) bacteria were detected, none of which were characterized as broadly resistant to antimicrobial agents. The only resistant bacteria recovered were two isolates of MRSA. There was a predominance of Gm (+) organisms of low virulence and pathogenicity. Authors reported that these data suggest the use of broad-spectrum antibiotics with efficacy against more resistant Gm (-) bacteria i.e. *Pseudomonas aeruginosa* and *Acinetobacter* spp. are unnecessary in early wound management.

Scott et al. (2007) reported on an outbreak of MDR *Acinetobacter baumannii-calcoaceticus* (ABC) complex infection, investigated in Iraq and Kuwait plus two military hospitals of initial treatment. They defined the outbreak, evaluated three potential sources of infection for March 2003 to December 2004, and screened surveillance cultures from patients’ skin, soil, and healthcare environments for the presence of ABC complex organisms. ABC complex was present on 1 (0.6%) of 160 patients screened and 1 (2%) of 49 soil samples. ABC isolates recovered from 7 of 7 (100%) of treatment areas samples. Pulsed-field gel electrophoresis (PFGE) identified five cluster groups in which patient isolates were related to environmental isolates. One
cluster consisted of patient who hadn’t been deployed to Iraq. Only imipenem, polymyxin B, and colistin demonstrated reliable in vitro antimicrobial activity among the clinical isolates. Environmental isolates were generally more drug susceptible than the clinical isolates. Authors suggest that environmental contamination of field hospitals and infection transmission within healthcare facilities played a major role in this outbreak. They advise that improved infection control throughout the military healthcare system is required and novel prevention strategies should be devised to prevent HAI in field hospitals.

Yun et al. (2006) documented unique MDRO bacteria characteristics recovered from veterans of OIF/OEF, differing substantially depending upon whether the infection is new vs. recurrent. Of 100 patients with 139 hospitalizations for osteomyelitis; 94 involved lower extremities, 43 upper extremities, and two of the axial skeleton. There were 103 initial admissions with initial episodes whereas 36 admissions were recurrences. Median age was 27 years and 95% were male. Duration of follow-up ranged from two weeks to 36 months. Patients with orthopedic devices had recurrent infections more frequently (26 vs. 5%, \( P < 0.01 \)). Bacteria, antibiotics, or infection site were not predictive of recurrence. Gram-negative pathogens including \textit{Acinetobacter} spp. (70 vs. 5%, \( P < 0.01 \)), \textit{Klebsiella pneumoniae} (18 vs. 5%, \( P = 0.04 \)), and \textit{Pseudomonas aeruginosa} (24 vs. 5%, \( P < 0.01 \)) were more likely to be recovered during the original episode than during recurrences. Gram-positive pathogens were more likely to occur during recurrences: \textit{Staphylococcus aureus} (13 vs. 53%, \( P < 0.01 \)), methicillin
susceptible *Staphylococcus aureus* (5 vs. 22%, $P < 0.01$), and methicillin resistant *Staphylococcus aureus* (MRSA) (8 vs. 31%, $P < 0.01$).
CHAPTER 3: METHODOLOGY
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This chapter provides details of study methods. It begins with a brief overview of the study, followed by the design, sampling, measurement, and data analysis. Patient factors were obtained from an existing database, Trauma Infectious Diseases Outcomes Study (TIDOS); thus a description of TIDOS is included in the sampling and measurement sections. The chapter concludes with a discussion of ethical considerations.

OVERVIEW

With the ongoing wars in Afghanistan and Iraq as well as U.S. military support of Arab people fighting for freedom in other countries, one result is that there are numerous U.S. service members suffering traumatic injuries and secondary infections. Research that focuses on the importance and outcomes of healthcare provider compliance to infection prevention protocols in war-wounded has not previously been sufficiently well-investigated in relation to military medicine in caring for those suffering trauma during modern wartime battles.

RESEARCH DESIGN

Documentation of this study is an observational, non-experimental, retrospective study of healthcare worker compliance to established infection prevention protocols for war-wounded patients following a deployment-related traumatic injury. It is epidemiologic research that describes the status quo and explores existing relationships
between variables (Polit & Beck, 2008, p. 63). TIDOS data were utilized in this study to explore new hypotheses and relationships specific to electronic documentation of infection prevention protocols carried out on the sample of war-related trauma subjects admitted to the National Naval Medical Center (NNMC) in Bethesda, Maryland upon transfer from Landstuhl Regional Medical Center (LRMC) in Landstuhl, Germany.

Questions regarding adherence to NNMC infection prevention protocols in relation to patient factors included:

1. What is the documented compliance rate to the infection prevention protocols regarding 1) ASC, 2) ISO, and 3) CHG bath decolonization by healthcare providers caring for U.S. war-wounded?
2. What patient factors are associated with compliance with the ASC procedure?
3. What patient factors are associated with compliance to clearance cultures/isolation procedure?
4. What patient factors are associated with compliance to the CHG bathing?

**STUDY POPULATION AND SAMPLE FOR THE PROPOSED STUDY**

The target population for this study was all deployed U.S. military or DoD beneficiary personnel experiencing traumatic injury in Iraq, Afghanistan, or another country and then transferred to LRMC. The cohort study sample was all deployed military or DoD beneficiary personnel experiencing traumatic war-related injury requiring admission to LRMC and then transferred for admission to NNMC. This study consisted of all NNMC admissions from LRMC (N = 2940) during the two calendar
years beginning June 1, 2009 and extending through May 31, 2011 (see Table 1., TIDOS Admission Numbers, on the next page). Inclusion criteria for this study were:

- Active duty or DoD beneficiary personnel ≥18 years old
- Wounded or injured during deployment requiring return to NNMC
- Admitted to NNMC from LRMC for the first post-evacuation continental U.S. (CONUS) hospitalization

Exclusion criteria for this study included the following:

- Burn injury

Pregnancy was non-exclusionary for participation in this study.

**TABLE 3.0: TIDOS ADMISSION NUMBERS**

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<th>Year</th>
<th>Jun-09</th>
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<th>Aug-09</th>
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65
DETERMINATION OF SAMPLE SIZE

According to Polit and Beck (2008, pp. 602-603), power analysis can be used to reduce risk for Type II errors by estimating in advance how large a sample size is needed in order to obtain statistically significant as well as clinically relevant results. Power analysis is a procedure to estimate either the likelihood of committing a Type II error or sample size requirements. Beta (\(\beta\)) is the probability of a Type II error (false negative). Therefore, the complement of beta (1 – \(\beta\)) is the probability of detecting a true relationship/group difference and is the power of the statistical test. In this study the assumptions are as follows: \(\alpha = .05\), the power (1 – \(\beta\)) is .80, and effect size (\(d\)) is the magnitude of the relationship between research variables. When effects (relationships) are strong, they can be detected at statistically significant levels even with small samples; when relationships are fairly small, large sample sizes are necessary to avoid Type II errors. Power analysis is used to estimate sample size requirements when the population effect size is unknown; if it were known, a new study wouldn’t be necessary. Effect size is calculated from whatever evidence is available. Lacking earlier relevant findings, researchers use conventions based on expectations of a small, medium, or large effect. Most nursing studies utilize modest effects. Polit and Beck (2008) suggest that a minimum sample size is five times as many cases as there are predictors in a regression; therefore, a minimum sample size for this study is 315. Therefore, by utilizing the entire sample consisting of 599 patients who were admitted to NNMC from LRMC for their first post-evacuation continental U.S. hospitalization, this should satisfy the need to avoid Type II errors.
STUDY VARIABLES AND MEASUREMENT

An operational definition is a definition of a concept or variable in terms of the procedures by which it is to be measured.

There were three types of infection prevention compliance assessed: active surveillance culture (ASC) collection, isolation (ISO) precautions adherence, and giving a chlorhexidine (CHG) cloth bath when indicated. All of these measures were dichotomous variables (compliant versus not compliant). All partially compliant measures are categorized as non-compliant. Specifically, these include documentation of ASC upon admission to NNMC, documentation of compliance to Isolation Precautions upon first admission for all patients plus as appropriate throughout any additional transfers or readmissions, and documentation of CHG cloth baths administered throughout any hospital sequence. This is a study of electronic medical records relevant to 236 war-wounded soldiers, sailors, and marines in relation to all available TIDOS data admitted to NNMC from LRMC between 01 June 2009 and 31 May 2011. Data were collected from November 2011 through February 2012.

Date of initial admission to NNMC was identified via the electronic medical record (EMR), and then entered onto the INFECTION PREVENTION/CONTROL DATA COLLECTION FORM (pp. 70-73). It was assessed as a date (mm/dd/yyyy).

Admission site location (Unit) and transfer (Unit) location(s) of patient were identified via the EMR plus entered onto the INFECTION PREVENTION/CONTROL DATA COLLECTION FORM. It was assessed as ICU, 5E, 5C, 5W, or 7E (1, 2, 3, 4, or 5). Any first Admission to NNMC from LRMC or readmission to NNMC following
discharge from NNMC was classified as Admission on page 1 of the INFECTION PREVENTION/CONTROL DATA COLLECTION FORM. Any transfer from one inpatient unit to another following such admission were then identified as Hospital Transfer #1, followed by Hospital Transfer #2, Hospital Transfer #3, and Hospital Transfer #4. This allowed for documentation of five inpatient sites (documented into sequences 1/2/3/4/5) within each hospital inpatient admission. Any subsequent admissions were documented on separate INFECTION PREVENTION/CONTROL DATA COLLECTION FORMs with additional sequences attributed to the same individual patient’s personal identifying number.

Active surveillance cultures (ASC) were identified via ID Module data. It was assessed as Yes/No (1, 0) and by Date Obtained (mm/dd/yyyy).

Isolation was identified via the EMR in Notes (Progress, Infection Control, Nursing, &/or Physical Therapy), Treatment (Treatment Orders), or Orders (Physician Orders) plus entered onto the INFECTION PREVENTION/CONTROL DATA COLLECTION FORM. It was assessed as Yes/No (1, 0).

Start Date and Stop Date for Isolation were each identified via the EMR plus entered onto the INFECTION PREVENTION/CONTROL DATA COLLECTION FORM. They were assessed as mm/dd/yyyy. Healthcare professional(s) who documented that Isolation would Start and Stop were identified via the EMR, designated by their profession, and entered onto the INFECTION PREVENTION/CONTROL DATA COLLECTION FORM as R = Nurse / C = Corpsman / D = Physician (2, 1, 0).
Administration of CHG cloth baths were surveyed in Notes (Progress, Infection Control, PreOp Prep, &/or Nursing), Treatment (Treatment Order, Treatment Sheets, Kardex), or Orders (Physician Orders) plus entered onto the INFECTION PREVENTION/CONTROL DATA COLLECTION FORM. It was assessed as Yes/No (1, 0).

Start Date and Stop Date for CHG baths were each identified via the electronic medical record (EMR) plus entered onto the INFECTION PREVENTION/CONTROL DATA COLLECTION FORM. They were each assessed as mm/dd/yyyy. Healthcare professional(s) who documented that CHG cloth bath will Start and Stop were identified via the EMR, designated by their profession, and entered onto the INFECTION PREVENTION/CONTROL DATA COLLECTION FORM as R = Nurse / C = Corpsman / D = Physician (2, 1, 0). The total number of CHG baths documented in the EMR was tallied and entered onto the INFECTION PREVENTION/CONTROL DATA COLLECTION FORM as a number (1, 2, 3, etc.).
Figure 3.0: INFECTION PREVENTION/CONTROL DATA COLLECTION FORM
### Hospital Transfer

<table>
<thead>
<tr>
<th>Date (mm/dd/yyyy):</th>
<th>Unit (Check One)</th>
<th>Isolation Y/N</th>
<th>CHG Bath Y/N</th>
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<tbody>
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<td></td>
<td>□ ICU</td>
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<tr>
<td></td>
<td>□ 5E</td>
<td></td>
<td></td>
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<td></td>
<td>□ 5C</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>□ 5W</td>
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</tr>
<tr>
<td></td>
<td>□ 7E</td>
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# PT Visits/Week in each Unit while on Isolation:

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<th>Start Date (mm/dd/yyyy):</th>
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Documented by: R/C/D

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Documented by: R/C/D

Total # Done:

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### Hospital Transfer

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<th>Date (mm/dd/yyyy):</th>
<th>Unit (Check One)</th>
<th>Isolation Y/N</th>
<th>CHG Bath Y/N</th>
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</tr>
<tr>
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<td></td>
<td>□ 5W</td>
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<tr>
<td></td>
<td>□ 7E</td>
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# PT Visits/Week in each Unit while on Isolation:

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<th>Start Date (mm/dd/yyyy):</th>
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Documented by: R/C/D

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<tr>
<th>Stop Date (mm/dd/yyyy) vs. X:</th>
<th>Stop Date (mm/dd/yyyy) vs. X:</th>
</tr>
</thead>
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Documented by: R/C/D

Total # Done:

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### Hospital Transfer

<table>
<thead>
<tr>
<th>Date (mm/dd/yyyy):</th>
<th>Unit (Check One)</th>
<th>Isolation Y/N</th>
<th>CHG Bath Y/N</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>□ ICU</td>
<td></td>
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<tr>
<td></td>
<td>□ 5E</td>
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<td></td>
<td>□ 5W</td>
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<td></td>
<td>□ 7E</td>
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# PT Visits/Week in each Unit while on Isolation:

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<th>Start Date (mm/dd/yyyy):</th>
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Documented by: R/C/D

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<th>Stop Date (mm/dd/yyyy) vs. X:</th>
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Documented by: R/C/D

Total # Done:
Definitions/Protocols:

ASC: Active Surveillance Cultures should be taken from original site plus bilateral groin (laboratory chit marked “MDRO GROIN”) for *Acinetobacter baumannii* (ACB).
ASC should also be taken from original site plus urine or peri-anal/rectal swab (Laboratory chit marked “r/o ESBL”) for (*Klebsiella, Pseudomonas/ Burkholderia/Stenotrophomonas, E. coli*, *Enterobacter, Proteus, Salmonella, or Serratia*) ESBLs and/or *Klebsiella pneumoniae* carbapenemases (KPCs).

In order to clear patient colonized/infected with Gm (-) MDRO, the patient must meet all of the following criteria:

1. Must be off effective antimicrobial therapy at least 72 hours (one to which the pathogen is sensitive).
2. Obtain three consecutive cultures at the sites directed above at least 72 hours apart.
3. All culture results must be finalized as negative prior to discontinuing Contact Precautions.

Isolation: Placed on Contact Precautions in a private room or cohort with another patient with the same pathogen and no other likely colonization/infection until appropriately obtained ASCs are finalized as negative for Gm (-) MDROs by Microbiology Laboratory.

CHG Bath:

- Intensive Care Unit
  - All OIF/OEF admissions will receive a chlorhexidine gluconate (CHG) cloth bath upon arrival to the ICU
  - CHG baths will be administered every 3rd day until final surveillance cultures are returned as negative for Gm (-) MDROs from Microbiology Laboratory
- Traumatic Brain Injured (TBI) Patients on Wards
  - Upon arrival to Ward, all OIF/OEF patients with suspected or diagnosed TBI who are colonized with Gm (-) MDR are bathed with CHG wipes daily for five consecutive days
  - Wait 24 hours following the last CHG bath has been administered before obtaining bilateral groin cultures to rule out continued colonization with ACB
  - Wait 24 hours following the last CHG bath has been administered before obtaining urine or peri-anal/rectal swab culture to rule out continued colonization with ESBLs
• Age: ratio level data obtained from ID MODULE DATA

• Country of deployment at date of injury: nominal data, OIF (Operation Iraqi Freedom), OEF (Operation Enduring Freedom [Afghanistan]), or Other identified as 1, 2, or 3 by ID MODULE DATA

• Date of injury: interval level obtained from ID MODULE DATA

• ISS: ordinal level data equal to the sum of squares for the highest values in each of the three most severely injured body regions (range 1-75)

  o Body regions for Injury Severity Score (ISS) Calculations
    1. Head or neck
    2. Face
    3. Thorax
    4. Abdomen
    5. Extremities
    6. External

According to Linn (1995), as a severity score, ISS can help adjust for differences among patients in the overall severity of injury and enable comparison of divergent populations without limiting analyses to identical injuries. These data were available via ID MODULE DATA.

• SOFA (Sepsis-related Organ Failure Assessment): continuous level data used to describe covering a total of six organs for a possible range of scores from 0 to 24. Available upon admission to an ICU and weekly (Vincent et al., 1996). Data were
available for this study via ID Module as assessed upon admission to LRMC ICU and admission to NNMC ICU.

- Presence of $\geq 1$ infectious co-morbidity: ordinal level via identification of infectious disease events from ID Module (Y/N, 1 or 0).

- Type of injury: nominal level data, Blast or NonBlast (1 or 2) available from ID MODULE DATA

- Anatomic site of injury: ordinal level of data identified via TIDOS – ID MODULE DATA Trauma Category Coding “Injury Pattern” (Tribble et al., 2011) per ID MODULE DATA

  - Solitary injury category
    - Skin/soft tissue + closed fracture(s)
    - Skin/soft tissue + open fracture(s), exposed bone, or open joints
    - Thoracic cavity (penetrating)
    - Abdomen (penetrating)
    - Maxillofacial – open fracture or fracture with foreign body or fixation device
    - CNS – penetrating brain injury
    - CNS – penetrating spinal cord injury
- Eye injury, burn, or abrasion
- Eye injury (penetrating)
- Burns
- Other (solitary injury)

  - Multiple injury categories (selected)
    - Soft tissue / fracture(s) (no open) ≥ 2 sites
    - Soft tissue / fracture(s) (≥1 open) ≥ 2 sites
    - Thoracic cavity (penetrating) + soft tissue/fractures (any)
    - Abdomen (penetrating) + soft tissue/fractures (any)
    - Thoracic + abdomen ± soft tissue/fractures (any)
    - Maxillofacial + soft tissue/fractures (any)
    - Maxillofacial + CNS (brain)
    - CNS (spinal cord) + Abdomen
    - CNS + Abdomen + Thoracic + Maxillofacial ± Soft tissue/fractures (any)
    - Other (multiple injury)
• **Infectious Disease (ID) Event**: nominal level data Y/N. If yes, further described by type along with date of diagnosis per ID Module/TIDOS database. Specific types of events include: None, BSI (bloodstream infection), CNS (central nervous system), Intra-abdominal, Intra-thoracic & Pulmonary, MDRO colonization, Osteomyelitis, Sepsis, Skin/Soft Tissue, and Other (specify).

• **Culture**: Nominal level (1 = Negative, 2 = Positive, 3 = Mixed Flora, 8 = N/A) identified via groin swab cultures per ID Module.

  The DV was documentation of adherence to active surveillance culture (ASC) protocol, empiric and laboratory-confirmed adherence to transmission-based isolation (ISO) precautions protocol, and chlorhexidine gluconate (CHG) bath protocols. The IVs were age, country of deployment, number of days between injury and admission, severity of injury (ISS), sequential organ failure assessment (SOFA), presence of infectious co-morbidities, type of injury, anatomic site of injury, infectious disease (ID) occurrence plus specific site if an ID event occurred, and active surveillance culture identification via groin swab culture.

  Research questions were first addressed using descriptive statistics (frequency and percentage). Next, pre-analysis data screening was conducted previous to examination of data for missing cases and outliers. Frequencies were tallied from lowest to highest with a count of the number of times each value was obtained.
**TABLE 3.1: STUDY VARIABLES**

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<th>Conceptual</th>
<th>Operational</th>
<th>References</th>
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<td><strong>IP Adherence</strong></td>
<td><strong>Within 1st 48h after admission to NNMC</strong></td>
<td><strong>Date ASC / Admission date</strong>&lt;br&gt;  - Yes/No (1,0)&lt;br&gt;  - Date Obtained mm/dd/yyyy&lt;br&gt;  - Isolation&lt;br&gt;  - Yes/No (1,0)&lt;br&gt;  - Start date mm/dd/yyyy&lt;br&gt;  - Stop date mm/dd/yyyy&lt;br&gt;  - No. of days&lt;br&gt;  - CHG bath date(s)&lt;br&gt;  - Yes/No (1,0)&lt;br&gt;  - ICU mm/dd/yyyy&lt;br&gt;  - Ward mm/dd/yyyy&lt;br&gt;  - # CHG baths</td>
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<td><em>Isolation (ISO) precautions</em></td>
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<td><em>CHG cloth bath administration</em></td>
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<td>Conceptual</td>
<td>Operational</td>
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<td>---------------------------</td>
<td>-------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Age</td>
<td>In years</td>
<td>Current year minus birth year per JTTR</td>
<td>Tribble et al., 2010</td>
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<tr>
<td>Country of deployment</td>
<td>Ref = Afghanistan (OIF) - Iraq (OIF) - Other</td>
<td></td>
<td>Tribble et al., 2010</td>
</tr>
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<td>Length of time pre admission to CONUS hospital</td>
<td>Time of injury to admission in U.S. hospital</td>
<td>Calculated via date of admission minus date of injury</td>
<td>Tribble et al., 2010, p. 35.</td>
</tr>
<tr>
<td>Sequential organ failure assessment (SOFA)</td>
<td>0-4 X 6 assessed upon LRMIC and NNMC ICU admission (available from Level 4/5 hospitals only) (Score = 5 is 'not available')</td>
<td>Describes mortality &amp; has demonstrated value in serial measurements plus is a reliable indicator of prolonged length of stay and death in trauma patients.</td>
<td>Vincent, J.L., Moreno, R., Takala, J., Willatts, De Mendonça, A., Bruning, H.,…Thijs, L.G. (1996). The SOFA (Sepsis-related Organ Failure Assessment) score to describe organ dysfunction/failed. Intensive Care Medicine, 22(7), 707-710. Tribble et al., 2010, p. 17.</td>
</tr>
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<td>Presence of infectious co-morbidities</td>
<td>Y/N, 1 or 0 per ID Module</td>
<td>Assumption of higher risk infection with co-morbidities</td>
<td>Tribble et al., 2010, p. 31.</td>
</tr>
<tr>
<td>Type of injury</td>
<td>Blast (1) or NonBlast (2) (per JTTR)</td>
<td>Contaminated/dirty wounds are assumed to put injured at greater risk of Gm (-) MDR infection.</td>
<td>Tribble et al., 2010, p. 17.</td>
</tr>
<tr>
<td>Anatomic site of Injury</td>
<td>Injury Pattern Code via JTTR injury narrative Solitary Injury Category 55 = SST, no open Fxs 59 = SST, open Fxs, exposed bone, or open joints 60 = Thoracic cavity (penetrating) 61 = Abdomen (penetrating) 62 = MaxFao - Open Fx or Fx with foreign body or fixation device 63 = CNS – Penetrating brain injury 64 = CNS – Penetrating</td>
<td>Assumption of higher risk infection with contaminated/dirty wounds and penetration of GI tract</td>
<td>TIDOG-JTTR Trauma Category Coding &quot;Injury Pattern Code&quot;</td>
</tr>
<tr>
<td>Spinal Cord Injury</td>
<td>Infection</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>-----------</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>65 = Eye Injury, Burn or Abroad</td>
<td>66 = Eye Injury (penetrating)</td>
<td>67 = Bums</td>
<td></td>
</tr>
<tr>
<td>68 = Other ( solitary injury)</td>
<td>Multiple Injury categories (selected)</td>
<td>Soft tissue/Fx (no open) ≥2 sites</td>
<td></td>
</tr>
<tr>
<td>69 = Soft tissue/Fx (no open) ≥2 sites</td>
<td>70 = Soft tissue/Fx (≥1 open) ≥2 sites</td>
<td>71 = Thoracic cavity (penetrating) + Soft tissue/Fxs (any)</td>
<td></td>
</tr>
<tr>
<td>72 = Abdomen (penetrating) + Soft tissue/Fxs (any)</td>
<td>73 = Thoracic + Abdomen + Soft tissue/Fxs (any)</td>
<td>74 = MaxFac + Soft tissue/Fxs (any)</td>
<td></td>
</tr>
<tr>
<td>75 = MaxFac + CNS (brain)</td>
<td>76 = CNS (spinal cord) + Abdomen</td>
<td>77 = CNS + Abdomen + Thoracic + MaxFac + Soft tissue/Fxs (any)</td>
<td></td>
</tr>
<tr>
<td>78 = Other (multiple injury)</td>
<td>79 = Other (multiple injury)</td>
<td>80 = N/A</td>
<td></td>
</tr>
</tbody>
</table>

**Infection**
- By specific site + date of infection via ID Module
- Culture
  - 1 = Negative
  - 2 = Positive
  - 3 = Mixed Flora
  - 8 = N/A

Per TIDSS CDC/NHIS criteria for infection

Per Microbiology Laboratory criteria

**References**
Demographic factor of age was operationalized by ID MODULE DATA identified on the electronic medical record (EMR) plus ID Module Data Collection Forms. It was assessed as ratio level (age in years).

Length of time between injury and admission to CONUS hospital, interval level data, was operationalized by ID MODULE DATA identified on the EMR plus ID Module Data Collection Forms and assessed by date of CONUS hospital admission minus the date of injury (number of days).

Injury Severity Scale (ISS), interval level data, were operationalized by ID MODULE DATA from the EMR (injury classification and severity scoring via sum of squares for total of 1 to 75).

Type of injury (Blast or NonBlast) was operationalized by ID MODULE DATA from the EMR as nominal level data (1 = Blast, 2 = NonBlast).

Anatomic site of injury was operationalized by ID MODULE DATA from EMR plus the TIDOS - ID MODULE DATA Trauma Category Coding “Injury Pattern” Code as nominal level data from Solitary Injury Category for various affected sites.

Presence of any Gm (-) pathogen was operationalized by JTTR from EMR plus ID Module Data Collection Forms per groin swab cultures results as nominal level data. Two categories will be used for this variable: Yes or No (2, 1).

A total compliance score relative to ASC, Isolation, and CHG bath cloth usage was computed by adding the dependent variable scores together with possible scores coding of each from 0 to 3. Dependent Variable (DVs) were dichotomous, with the
possible results as follows: ASC Yes (1), ASC No (0), Isolation Yes (1), Isolation No (0), CHG bath Yes (1), and CHG bath No (0).

Presence of infectious co-morbidities was identified from EMR through ID Module Data Collection Forms as nominal level data. Three categories were identified as Yes/No (1, 0) in relation to indicate that at least one infectious disease event occurred. If Yes, identified by type (BSI, CNS, Intra-Abdominal, Intra-Thoracic & Pulmonary, MDRO Colonization, Osteomyelitis, Sepsis, Skin/Soft Tissue, Other) with the specific type identified along with the date of diagnosis (ddmmmyy, e.g., 05Apr12). Each infectious event was characterized by the presence/absence of a culture (1 = Negative, 2 = Positive, 3 = Mixed Flora, 8 = N/A).

SOFA sequential organ failure assessment score was operationalized from ID Module forms for subjects upon admission to LRMC and NNMC ICUs and identified as interval level data of six organ systems, with categories related to Respiratory Function, Coagulation, Hepatic Function, Cardiovascular Function, Neurological Function, and Renal Function (with scores of 0 to 4 for each system X6).

PARTICIPANTS

Population: U.S. war-wounded service members cared for at LRMC and then transferred to one of three participating military hospitals in CONUS 01 June 2009 through 31 May 2011.

The study population was all deployed military or DoD beneficiary personnel experiencing traumatic injury requiring admission to LRMC and then transfer to NNMC.
Sample: The sample (n = 236) for this study was available data related to all war-injured admitted to NNMC (N = 599) via LRMC (N = 2,940) from June 1, 2009 through May 31, 2011 for Level V care (definitive treatment and rehabilitation) at NNMC.

Dependent variables (DVs) were infection prevention adherence measurements for 1) active surveillance cultures (ASC), 2) isolation precautions, and 3) CHG bath administration. They were collected by the researcher via the EMR and the INFECTION PREVENTION/CONTROL DATA COLLECTION FORM.

TIDOS data provided included compiled data from the Joint Theater Trauma Registry (JTTR) and the Navy-Marine Corps Combat Trauma Registry (CTR). The USU Infectious Diseases Clinical Research Program (IDCRP) team’s Data Coordinating Center (DCC) provided the dataset.

PROCEDURE FOR DATA MANAGEMENT / DATA ANALYSIS PLAN

Study variable data were keyed into Statistical Analysis System (SAS) via double data entry from source documents by a TIDOS researcher plus the researcher to ensure correct data entry. A log was devised and kept to document management of the data.

Once the database was created and entered, analyses were conducted to describe and answer the research questions. All data were converted by the DCC team and transferred to the researcher via a passcode protected site into files that could be analyzed using SPSS, PASW Statistics Version 18.00 (2009). All data were analyzed using SPSS, PASW Statistics Version 18.0 (2009). The first step in the data analysis plan was to screen data to identify the amount of missing data. Variables with greater than 15% of data missing were assessed for pattern: missing at random or systematic. Methods for
replacing missing data (i.e. mean or median replacement) were done as appropriate and were estimated using prior knowledge or a well-educated guess. Specifically, 16 missing variables for Age (range 19-46, \( \bar{X} = 24.2, SD = 4.7 \)) were substituted with the mean Age of 24. Next, statistical assumptions were checked accordingly, such as a check for linearity, normality and homoscedasticity for multivariate regression. Data were transformed as deemed necessary (Mertler & Vannatta, 2010).

Logistic regression was used for analyzing each of the dependent variables: ASC, Isolation, and CHG bath because they were all Yes/No (1, 0) values. This analysis predicted a probability, ranging from zero to one, that the subject had documentation that they were 1) screened for Gm (-) MDR, 2) placed on isolation precautions upon admission plus any other times during their admission when they were found to be infected or colonized with a Gm (-) MDR, then removed if/when their clearance cultures were negative, and 3) provided CHG cloth baths per ICU protocol or preoperative preparation protocol.

ICU protocol called for all war-wounded to be bathed with CHG cloths upon admission and then on every third day while they were housed in the ICU unit. Preoperative preparation protocol for war-wounded called for such patients to be bathed with CHG clothes both the night preceding surgery and on the morning of surgery before the patient was transported to the operative suite.

Descriptive statistics were utilized to describe and summarize the data collected on demographic data related to the subjects constituting the pilot sample. These data
included frequency distributions, mean, standard deviation, and univariate measures of association for each variable, with the range of data where appropriate.

Initially, data were screened for missing data, multivariate outliers and multicollinearity. Preliminary multiple Linear Regression was conducted to calculate Mahalanobis’ distance and to evaluate multicollinearity among the continuous variables: age, length of time of injury between date of injury and date of admission to NNMC, severity of injury (ISS), sequential organ failure assessment (SOFA), and anatomic site of injury. Logistic regressions output included three parts: statistics for overall model fit, classification table, and summary of model variables. Statistics for overall model fit provided several indices of model fit: -2 Log Likelihood, Cox & Snell R Square, and Model Chi-Square. A good-fitting model would typically have fairly low values for -2 Log Likelihood, significant model chi-square, and variables with odds ratios greater than one.

DATA COLLECTION TOOL AND PILOT TEST

It was critical to have a reliable and valid instrument to avoid weak, inaccurate or invalid results. Reliability addresses the consistency of the measures in the instrument; whereas validity looks at whether an instrument is measuring what it was intended to measure (Polit & Beck, 2008).

Pilot testing was accomplished via a paper and pencil tool filled out via accessing the electronic medical record (EMR), the Essentris® electronic healthcare database and the microbiology laboratory database (Composite Health Care System/CHCS). The
researcher obtained access to these military security card accessed, passcode-protected databases via the NNMC Information Technology (IT) Department. The collection form was devised by the researcher and was uniquely created as a pilot for an additional Supplemental Data Collection Form within the ID MODULE DATA COLLECTION FORMS of the oversight TIDOS project. All ID MODULE DATA COLLECTION FORMS are formatted similarly, designed to capture data occurring from the patient’s treatment at Level I through Level V MTFs. The project has been ongoing since 2008 with data gathering tools devised to meet the diverse needs of the unique military electronic medical record system that are available throughout levels I-V and in response to large influxes of critically wounded marines and soldiers from the battlefield/first aid all the way to the three CONUS definitive treatment/rehabilitation major tertiary care centers. Each data collection tool, in order to avoid redundancy while still remaining connected to the growing TIDOS database, must contain the randomly-generated unique identifier (patient identification number referred to as PID) before all de-identified data is exported into the study database. A data custodian retained the link between the assigned identification number from the ID MODULE DATA and the randomly-generated PID number. The reliability of this measuring instrument must be equal to its stability, consistency, or dependability. This also depends on its accuracy. These characteristics were tested via the inter-rater reliability of two people reviewing the same charts independently and then comparing their data as described in the following paragraphs. Because microbiology laboratory data and infectious diagnosis data were already identified via other ID MODULE DATA COLLECTION FORMS, the INFECTION
PREVENTION/CONTROL DATA COLLECTION FORM needed to include the PID, Facility Number, and Level of Care that are noted on every other TIDOS data collection form, but not repeat documentation that is already available via other forms. Thus, the INFECTION PREVENTION/CONTROL DATA COLLECTION FORM concentrated on documentation of transfer locations of units within the facility, initiation of ISOLATION precautions, and CHG baths. These data were entered into the all-encompassing TIDOS database for descriptive analyses and description of general approaches for analyses of study questions. Additionally, outcomes could be broadly categorized in terms of the timeframe in which they occurred. Use of data collected in the field and at LRMC was available for all evacuees, affording an opportunity to utilize key information regarding their original trauma, etc.

The initial INFECTION PREVENTION/CONTROL DATA COLLECTION FORM was devised using an easily filled out, left-to-right, flow-chart manner starting with Date, then Unit, ASC Yes/No with Date Obtained, Isolation Yes/No with Start/Stop Dates, and CHG Bath Yes/No with Start/Stop Dates. Thus the tool met all required documentation elements for the study: 1) Admission Date and Location for determination of active surveillance culture (ASC), 2) initiation of isolation precautions Yes/No (plus Stop and Start dates), and 3) CHG bath Yes/No (plus Stop and Start dates). These were repeated four times on one sheet allowing for the possibility of four location changes that might be made during a patient’s hospitalization.
For the first pilot test of the data collection tool the researcher requested personal identification numbers of any 10 randomly selected charts of NNMC TIDOS subjects. This was to identify documentation of active surveillance cultures upon admission, initiation of isolation precautions and any resulting clearance culture compliance, and specifics related to decolonization via administration of chlorhexidine gluconate (CHG) cloth baths. Two of the numbers were identical, so a total of nine EMRs were reviewed. The researcher was successful in reviewing the EMRs, but the exercise was time-intensive and the CHCS system was not functioning. Without also having access to CHCS, insufficient data were obtained for all the required elements. At the rate of two hours to review nine records and without the capability of obtaining laboratory data it was not conceivable that the process could succeed without access to both electronic databases.

The second pilot test was accomplished with a streamlined data collection tool devised with greater understanding and appreciation of microbiology laboratory data already available via the TIDOS database. This INFECTION PREVENTION/CONTROL DATA COLLECTION FORM was devised in a greatly scaled-down format in a more easily filled-out left-to-right, flow-chart manner starting with Date, then Unit, Isolation Yes/No with Start/Stop Dates, and last CHG Bath Yes/No with Start/Stop Dates. These were repeated four times on the sheet allowing for the possibility of four location transfers that might be necessary during a patient’s hospitalization. The researcher
estimated that it would take approximately 20 minutes to complete each of the 599 subjects’ INFECTION PREVENTION/CONTROL DATA COLLECTION FORMs.

EMR consistency was ensured by using a single organized approach to surveillance of each record:

1) Researcher access → Essentris®, 2) unarchive EMR via use of unique hospital number, 3) call up patient Admission Summary, 4) obtain admission (and discharge) date, 5) note if traumatic brain injury (TBI) was suspected/diagnosed, 6) transfer to Notes and alphabetize Notes for ease in determining any documentation of Isolation, Stop/Start Dates, or references to CHG cloth baths including Stop/Start Dates, Preop Prep, or references to CHG cloth baths including Stop/Start Dates, or trips made outside of Isolation room for Physical Therapy (PT), 7) click on “★” to call up All Notes from entire hospitalization to review all notes for Isolation Yes/No and CHG Yes/No and any of their Start/Stop Dates, then, if surveillance on this patient is complete, 8) transfer to Treatment Orders and Kardex to determine if any references were made to Isolation Precautions or CHG cloth utilization, 9) transfer to Nursing Treatment Sheets to review for all dates of their hospitalization for references to CHG cloth usage and isolation precautions, and 10) return to step two to unarchive the next patient via his/her unique hospital number.

Thus the researcher requested 10 randomly selected charts of TIDOS subjects who were admitted to NNMC between June 01, 2009 and May 31, 2010. Along with a second IDCRP researcher, the researcher pilot tested the INFECTION PREVENTION/CONTROL DATA COLLECTION FORM for inter-coder reliability (Polit & Beck, 2008). This was to test for the degree to which two coders, operating
independently, agree on coding decisions. The coders discussed the layout of the form as well as the various screens in the electronic medical record (EMR) where various data should be available to ensure that the recorded information would be accurate. Each coder then worked on the pilot independently in adjoining rooms until the computer system went down, at which time they had to discontinue. It was agreed that the two reviews completed by the second researcher would be utilized for inter-rater reliability and a third researcher would complete the review of the remaining eight records on another date when the computers would be functional. All required elements were searched and documented as seen on the EMR. Initial inter-rater agreement was 91% and any disagreements were resolved by discussion.

**INFECTION PREVENTION COMPLIANCE DATA COLLECTION**

What is the rate of documented compliance with infection prevention protocols regarding 1) active surveillance cultures (ASC), 2) isolation via Contact Precautions, and 3) administration of CHG cloth baths by healthcare providers caring for U.S. war-wounded?

a. While the sample size was to have been equal to the total of all NNMC TIDOS patients (June 2009-May 2011) N = 599, the actual number of cleaned data files available for this pilot study was n = 236.

These patients should be treated following the protocol described on Page 4 of the INFECTION PREVENTION/CONTROL DATA COLLECTION FORM.
i. If colonized, but not infected,
   a. Follow decolonization protocol on page 71
   b. Then follow Gm (-) MDR Clearance Culture Protocol

ii. Culture for the third time after 72 hours and discontinue isolation if after total of three consecutive sets of negative cultures finalized by Microbiology laboratory.

iii. Discontinue Contact Precautions

b. Electronic medical record (EMR) were reviewed to examine patient location(s)/transfers, isolation precautions initiated/discontinues, and CHG baths initiated/discontinued. The outcomes for this compliance variable were Yes / No (1, 0).

   i. Variables:

   1. Date: mm/dd/yyyy

   2. Location: ICU, 5E, 5C, 5W, 7E (1, 2, 3, 4, 5)
      a. Tally number of Physical Therapy visits per week in each unit while on Isolation

   3. Isolation Y/N (1, 0)
      a. If Yes, Start date: mm/dd/yyyy
      b. If Yes, End date: mm/dd/yyyy

   4. CHG bath Y/N (1, 0)
      a. If Yes, Start date: mm/dd/yyyy
b. If Yes, End date: mm/dd/yyyy

c. Enter number of times CHG baths were
documented in each unit

ii. Statistics: descriptive

Data for this study were gathered by the researcher via two methods. The first was via electronic download of TIDOS data previously gathered and entered by IDCRP research personnel. The second was via EMR review by the researcher for determination of adherence to active surveillance cultures (ASC), isolation protocol adherence, and use of CHG cloth baths to identify the following:

- **ICU Admission of study subjects:**
  - Empiric Contact Precautions (isolation) initiated
  - Bathe with 2% chlorhexidine gluconate (CHG) cloths (Sage® 2% Chlorhexidine Gluconate Cloths, ©Sage Products, Inc. 1997-2011, Cary, IL 60013)
    - Within 24 hours of admission
    - Plus bathe every three days until final surveillance cultures return as negative
  - Contact Precautions discontinued if initial ASCs negative for pathogens requiring transmission-based isolation precautions

- **Ward admission of study subjects**
  - Empiric Contact Precautions isolation initiated
  - Contact Precautions discontinued if initial ASCs negative for pathogens requiring transmission-based isolation precautions
• If appropriate treatment was given for infection and patient no longer seems to be infected or Decolonization Protocol was completed, follow Clearance Culture Protocol regarding CHG cloth baths.

The following describes the definition of compliance/noncompliance for Culture:

• Culture Compliance was documented in the electronic medical record as:

  0 = No (not obtained)
  1 = Yes (obtained)
  2 = Undocumented/Unclear (not specified in TIDOS data)

• For each patient’s Admission, Transfer, or Readmission to the National Naval Medical Center (NNMC) Culture results were documented as:

  1 = Negative
  2 = Positive (for epidemiologically important pathogen)
  3 = Mixed Flora (not epidemiologically important, normal skin flora)
  8 = Not applicable (N/A)

*Isolation Compliance* was calculated in the following ways:

• Upon Initial Admission, Transfer, or Readmission Isolation Compliance dichotomous variables were identified in the EMR related to the following:

  1 = Yes, Total Compliance to *ALL* following:
    • Start Date
- Documentation of Start by RN/Dr
- Stop Date
- Documentation of Stop by RN/Dr

2 = Partial: Start date, but no Stop date

3 = Partial: No Start date, but has Stop date

4 = Partial: Neither Start nor Stop date

5 = Partial: No Stop date + no documentation by RN/Dr at Stop Date

6 = Partial: No Start date + no documentation of Start date by RN/Dr

7 = Partial: Stop date, but no Stop date documentation by RN/Dr

8 = Partial: Start date, but no Start date documentation by RN/Dr

9 = Partial: Start date, but no Start documentation by RN/Dr +

10 = Partial: Stop date, but no Stop documentation by RN/Dr

11 = Partial: No Start documentation nor Stop documentation by RN/DR

12 = Total Non-Compliance: Neither Start date nor Stop date + neither Start nor Stop documented by RN/Dr

In analysis this variable was also coded as a dichotomous variable with:

Yes: Total Compliance and

No: Either Partial or Total Non-Compliance

• For Culture episodes not associated with an Admission, Readmission, or Transfer; assessment for Isolation Compliance, dichotomous variables were identified in the electronic medical record in the electronic medical record as follows (however, for
analysis purposes, Compliance was designated as Yes = Total Compliance to ALL vs. No or Partial = Non-Compliance):

0 = No, Non-Compliant
1 = Yes, Compliant
   o Fully Compliant if patient has Culture obtained on a date documented as s/he was on Isolation Precautions
   o Fully Compliant if Isolation for the identified pathogen is not required
2 = Undocumented/Unclear

The final dichotomous variables were:

Yes: Total Compliance
No: Either Partial or Total Non-Compliance

• For a Readmission or Transfer episode, the assessment for Isolation Compliance is documented as follows for patients not on Isolation Precautions:

3 = Not Applicable (N/A) if patient is not on Isolation Precautions

For each culture that was not associated with an Admission, Transfer, or Readmission to NNMC, if Isolation Precautions were not required, then Culture Compliance was identified as Compliant. For example, in cases where a patient’s groin culture grew coagulase negative *Staphylococcus*, that patient episode would be assessed as Compliant for Isolation, even though the patient was not on Isolation Precautions.

*Chlorhexidine Gluconate (CHG) Bath Compliance* was calculated similarly as for ISO:
• Upon Initial Admission, Transfer, or Readmission, dichotomous variables were identified in the electronic medical record related to the following:

1 = Yes, Total Compliance to *ALL* following:
   - Start Date
   - Documentation of Start by RN/Dr
   - Stop Date
   - Documentation of Stop by RN/Dr

2 = Partial: Start date, but no Stop date
3 = Partial: No Start date, but has Stop date
4 = Partial: Neither Start nor Stop date
5 = Partial: No Stop date + no documentation by RN/Dr at Stop Date
6 = Partial: No Start date + no documentation of Start date by RN/Dr
7 = Partial: Stop date, but no Stop date documentation by RN/Dr
8 = Partial: Start date, but no Start date documentation by RN/Dr
9 = Partial: Start date, but no Start documentation by RN/Dr +
10 = Partial: Stop date, but no Stop documentation by RN/Dr
11 = Partial: No Start documentation nor Stop documentation by RN/DR
12 = Total Non-Compliance: Neither Start date nor Stop date + neither Start nor Stop documented by RN/Dr

Additionally, all evidence of CHG baths documented in the electronic medical record would be calculated as a total number and tallied by Sequence. In analysis,
compliance was also coded as a dichotomous variable with total compliance and non-compliance (partial or total non-compliance).

**DATA SOURCE: TRAUMA INFECTIOUS DISEASE OUTCOMES STUDY (TIDOS)**

Covariates were obtained from TIDOS. TIDOS is an observational cohort study of short and long term infectious disease outcomes following deployment-related injuries. There were 15 different ID Module data collection forms for all levels of care from theater levels (Level I-III) through LRMC and CONUS levels (Levels IV-V); plus supplemental data collection forms related to specific infection sites, antimicrobial therapy, microbiology data, operating room visits and death.

Population is U.S. war-wounded service members cared for at LRMC and then transferred to one of three participating military hospitals in CONUS. The TIDOS sample includes all deployed military or DoD beneficiary personnel with traumatic injury requiring transfer to LRMC followed by medical evacuation to one of the three participating CONUS hospitals. The patients are young, predominately male, military personnel from the Army, Navy, Marine Corps, Air Force, or civilian DoD beneficiaries who have been wounded while deployed overseas. The majority of medical evacuees are admitted via LRMC to three CONUS MTFs: NNMC (converted into Walter Reed National Military Medical Center WRNMMC in September 2011, but referred to as NNMC throughout this study), Walter Reed Army Medical Center (WRAMC) that
closed/merged into the WRNMMC, and Brooke Army Medical Center (BAMC); thus, those MTFs were selected as study enrollment sites.

TIDOS data began being collected in June 2009 and continues to the present. Data related to war-wounded service members cared for at LRMC and then transferred to one of three participating military hospitals in Continental United States (CONUS) are captured in the TIDOS electronic database. This was an observational cohort study of infectious disease outcomes following deployment-related traumatic injury in active duty personnel or DoD beneficiaries from Level IV, Level V, to post-hospitalization follow-up. Level IV care was in the fixed facility European medical/surgical care administered at LRMC. TIDOS study Level V care for definitive treatment and rehabilitation occurred at NNMC in Bethesda, Maryland; WRAMC in Washington, District of Columbia (now closed and merged into WRNMMC); and BAMC in San Antonio, Texas. Bed capacity for each participating hospital is LRMC = 310, BAMC = 450, NNMC = 500, and WRAMC = 236. This study examined TIDOS admissions to NNMC from June 2009 through May 2011.

The number of admissions to LRMC (shown in Table 3.0) is shown from initiation of study in June 2009 through May 2011. Total number of TIDOS admissions in that period was 2,940. Of those injured U.S. service members admitted to LRMC, the following have been transferred for admission to the three participating CONUS military hospitals: BAMC (N = 356), NNMC (N = 599), and WRAMC (N = 596).

All trauma patients admitted to LRMC and entered into Joint Theater Trauma Registry (JTTR) were entered into the general study population. Trauma history and
inpatient clinical management during hospitalization(s) at the four participating medical treatment facilities (MTFs) were obtained on all subjects through queries of ID MODULE DATA and U.S. Navy-Marine Corps Combat Trauma Registry (CTR) databases. The ID MODULE DATA has an additional component capturing more specific information related to infectious diseases than the deployment ID MODULE DATA and CTR databases collected on traumatic injuries while subjects remained deployed overseas.

The bacterial isolate unique identification number retains the link between clinical and microbiological data without individual identifiers. This de-identified aspect of the protocol, a prospective analysis of the overall trauma patient data as it relates to infectious disease outcomes objectives along with investigations of the collected bacteria, conforms with criteria that defines research that doesn’t involve human subjects. There is no intervention or interaction with the subjects AND the information is not individually identifiable.

Trauma history and clinical management data were captured by the Essentris® electronic healthcare database, ID MODULE DATA, and electronically transferred to the study database.

Data from the ID MODULE DATA, without personal identifiers, were securely exported to the Data Coordination Center (DCC) in Rockville, Maryland on a monthly basis with each subject’s data coded via ID module number that was used in the ID MODULE DATA.
To provide internal and external comparability of traumatic injured patients, it was necessary to utilize validated scoring systems; both for initial assessment of injuries and all subsequent interval health assessments. TIDOS uses the Injury Severity Score (ISS), the most commonly applied for injury classification and severity scoring and has been used in numerous evaluations of OIF/OEF patients (Petersen et al., 2007; Linn, 1995; Eastridge et al., 2006; and Dunne et al., 2006).

Standardized definitions for healthcare associated infections (HAIs) were utilized by implementing CDC National Healthcare Safety Network (NHSN) criteria, combining a combination of clinical findings and laboratory/other test results to determine the presence and classification of infections.
HUMAN SUBJECTS PROTECTION CONSIDERATIONS

A data security firewall was established at DCC with an assigned data custodian not involved with other aspects of the TIDOS project. ID MODULE DATA-exported data received at DCC were received by the data custodian who assigned each non-enrolled subject data record a randomly-generated unique identifier (patient identification number or PID); enrolled subjects have a PID number assigned by the coordinator(s) at the enrollment site. The de-identified data are then exported into the study database.

The following approvals have been obtained by the following authorities: IDCRP Scientific Review Board, approved November 10, 2008; ethical review by Uniformed Services University (USU) Infectious Disease Institutional Review Board (ID IRB- IRB of Record IDCRP-024), April 15, 2009; plus participating site commander or designee at Brooke Army Medical Center, May 25, 2009; National Naval Medical Center, May 18, 2009; Walter Reed Army Medical Center, April 21, 2009; Landstuhl Regional Medical Center April 21, 2009; Walter Reed Army Institute of Research, April 20, 2009; and United States Army Institute of Surgical Research, June 1, 2009. Data analysis of TIDOS has been approved by the Uniformed Services University ID IRB Site Protocol Number IDCRP-024, with ethical considerations lessened due to the deletion of personal identifiers. That de-identified data can be exported into the study database. Since there were be no personal identifiers or sensitive information recorded and this study was designed to become a part of TIDOS, it was submitted as an amendment to the IDCRP IRB-024 on 21 September 2011 and approved on 03 November 2011 (see APPENDIX A,
page 127). It was then submitted to George Mason University Human Services Review Board (HSRB) for expedited approval as an already-approved study under IDCRP IRB-024. The HSRB found that there was no need to review the work since there was no information to be gathered regarding any individual human subject (see APPENDIX B, page 128).

**DATA ANALYSIS**

The characteristics of the sample are discussed followed by a description of the results pertinent to each research question. Dates of injury ranged from 30 May 2009 through 18 April 2011. Many experienced numerous subsequent transfers and readmissions to NNMC through May 2011. The Illness Severity Score (ISS) was calculated one time for each individual during each person’s initial assessment at LRMC. Age was used as a continuous variable as well as a categorical variable, with 19 to 24 years as the reference Age category, 25 to 30 years as (1) and older than 30 as (2). A logistic regression was first performed using Age as the continuous variable, then the same analysis was repeated using Age as a categorical variable.

The number of days each participant had been injured upon admission to NNMC was categorized into two categories as ≤5 days (reference) versus >5 days (1). To facilitate the interpretation of results, this variable was re-coded into two categories, with 0 to 5 as the reference category (0) and 6 to 20 as the comparison category (1).

Wound site was recoded Anatomic Site of Injury into three categories based on frequency and physical site. Head, arms/hands, and body were coded as 0 (reference),
legs and feet were re-coded as 1, while the other categories remained as a separate category (2). Further examination of this variable showed a large amount of missing data.

Since sequential organ failure assessment (SOFA) is a way to describe morbidity and has demonstrated value in serial measurements plus is a reliable indicator of prolonged length of stay and death in trauma patients, SOFA scores were calculated upon admission into LRMC’s ICU or Ward. In this study, only the first SOFA score was used.

The organization of data for this study was accomplished via dividing each inpatient encounter at NNMC into successive inpatient Sequences. Therefore, the first admission to NNMC was labeled Sequence #1. Three types of infection prevention compliance were assessed: active surveillance culture collection, isolation precautions adherence, and giving a chlorhexidine gluconate cloth bath when indicated. All of these measures were dichotomous variables (compliant versus partially/non-compliant). Specifically, these included documentation of an ASC upon admission to NNMC, documentation of compliance to Isolation Precautions upon first admission for all patients plus as appropriate throughout any additional transfers or readmissions, and documentation of CHG cloth baths administered throughout any hospital sequence.

Patients who were on Isolation Precautions were considered in TOTAL COMPLIANCE with the protocol when there was documentation in the electronic medical record of both Start Date and End Date plus initiation and discontinuation of the need for Isolation Precautions each documented by either a Nurse or a Physician. PARTIAL COMPLIANCE occurred when any of the four requirements for TOTAL

103
COMPLIANCE were missing. When Isolation Precautions were not necessary or not applicable, those cases were not assessed for compliance.

Of interest to both TIDOS and this study, the number of times per week that war-wounded patients were allowed to leave their isolation rooms to work out in Physical Therapy was tallied via ESSENTRIS notes written by Physical Therapists.

**SUMMARY**

This chapter discussed the methods for the proposed study as well as provided an overview of TIDOS. The pilot study was an exploratory, observational, non-experimental, retrospective study of healthcare provider compliance to established infection prevention protocols via documentation in the electronic medical record in caring for hospitalized war-wounded patients following a deployment-related traumatic injury. Active surveillance cultures, initiation and maintenance of isolation precautions, and providing chlorhexidine gluconate baths were not actual independent events, but closely-related events. The study focused on all trauma subjects injured in war-zones of Iraq and Afghanistan who were then admitted to the National Naval Medical Center upon transfer from Landstuhl Regional Medical Center between 01 June 2009 and 31 May 2011. Methods for data management and analysis were explained. Research questions were answered using statistical methods: logistical regression and multiple regression. Ethical considerations were provided.
CHAPTER 4: RESULTS
CHAPTER 4: RESULTS

SAMPLE

In total, 236 war-wounded sailors, soldiers, and marines were included in this study. Subjects ranged in age from 19 to 46 years (\( \bar{x} = 24.2, \ SD = 4.7 \)), with the majority (69.5%, \( n = 164 \)) of whom were 24 years of age or younger. The majority of subjects (66.5%, \( n = 147 \)) were injured from two to five days before admission to NNMC, although the range was 2 – 52 days. Nearly all (89.8%, \( n = 211 \)) were injured during Operation Enduring Freedom (OEF in Afghanistan). Injury Severity Scores (ISS) ranged from 1 – 45 that were organized into three categories consisting of 1-9 (38.2%, \( n = 83 \)), 10-20 (31.3%, \( n = 68 \)), and >20 (30.4%, \( n = 66 \)).

There were 182 SOFA scores from Landstuhl Regional Medical Center (LRMC) ranging from 0 – 20 (SD = 4.2, \( \bar{x} = 4.3 \)). A score of Zero occurred in 54 (29.7%) reports, which was the most frequent finding. A Score of 5 occurred 36 (19.8%) times, the Score of 6 occurred 23 (12.6%) times, and the Score of 1 occurred 21 (11.5%) times. There were 183 initial SOFA scores tabulated upon admission to NNMC’s ICU ranging from 0 – 20 (SD = 4.0, \( \bar{x} = 4.0 \)). The highest frequency was for Zero occurring 58 (31.7%) of the time, then followed by Score of 5 occurring 35 (19.1%), Score of 6 occurring 23 (12.6%), and Score of 1 occurring 19 (10.4%) of the time. Weekly SOFA scores were tabulated in NNMC’s ICU a total of 157 times without variation and not utilized in this study.
The most common Patient Injury Pattern was within the Multiple Injury Category (80.8%, n = 63). Almost all subjects (90.8%, n = 198) were classified as having a “Blast” injury. Traumatic brain injury was suspected or diagnosed in 134 (56.5%) of participants. A full list of subject demographics is provided in Table 4.0 beginning on this page.

<table>
<thead>
<tr>
<th>TABLE 4.0: PARTICIPANT DEMOGRAPHICS (n = 236)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>Age</td>
</tr>
<tr>
<td>Age Categories</td>
</tr>
<tr>
<td>19-24</td>
</tr>
<tr>
<td>25-30</td>
</tr>
<tr>
<td>&gt;30</td>
</tr>
<tr>
<td>Days Injured upon NNMC Admission</td>
</tr>
<tr>
<td>Minimum – Maximum (2-52)</td>
</tr>
<tr>
<td>2-5</td>
</tr>
<tr>
<td>6-9</td>
</tr>
<tr>
<td>10-11</td>
</tr>
<tr>
<td>&gt;11</td>
</tr>
<tr>
<td>Military Operations Site</td>
</tr>
<tr>
<td>OIF (Iraq)</td>
</tr>
<tr>
<td>OEF (Afghanistan)</td>
</tr>
<tr>
<td>Not Documented</td>
</tr>
<tr>
<td>Injury Severity Score (ISS)</td>
</tr>
<tr>
<td>Minimum – Maximum (1-45)</td>
</tr>
<tr>
<td>1-9</td>
</tr>
<tr>
<td>10-20</td>
</tr>
<tr>
<td>&gt;20</td>
</tr>
<tr>
<td>LRMC SOFA Scores</td>
</tr>
<tr>
<td>Minimum – Maximum (0-20)</td>
</tr>
<tr>
<td>0-5</td>
</tr>
<tr>
<td>6-10</td>
</tr>
<tr>
<td>11-20</td>
</tr>
<tr>
<td>Initial NNMC SOFA Score</td>
</tr>
<tr>
<td>Minimum – Maximum (0-20)</td>
</tr>
<tr>
<td>Site of Injury (per Injury Pattern Codes)</td>
</tr>
<tr>
<td>----------------------------------------</td>
</tr>
<tr>
<td>Solitary Injury Category</td>
</tr>
<tr>
<td>Multiple Injury Categories (Selected)</td>
</tr>
<tr>
<td>Type of Injury</td>
</tr>
<tr>
<td>Blast</td>
</tr>
<tr>
<td>Non-Blast</td>
</tr>
<tr>
<td>Traumatic Brain Injury (TBI)</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
</tr>
</tbody>
</table>

**DESCRIPTION OF ENCOUNTERS/INPATIENT SEQUENCES**

There were a total of 489 infection prevention encounters that consisted of initial admission to NNMC followed by any in-hospital transfer or readmission following discharge. Most of the encounters occurred during Sequence 1, the first admission to NNMC (48.5%, n = 236) or Sequence 2, following transfer or readmission (23.8%, n = 117). Table 4.1 (page 109) provides a full description of infection prevention encounters.
TABLE 4.1: DESCRIPTION OF SEQUENCES

<table>
<thead>
<tr>
<th>Inpatient Sequences/Infection Prevention Encounters</th>
<th>Encounters n = 489</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\bar{x} = 2.2$, SD 1.8</td>
</tr>
<tr>
<td></td>
<td>n (%)</td>
</tr>
<tr>
<td>Admission (First Inpatient Encounter at NNMC)</td>
<td>236 (48.4%)</td>
</tr>
<tr>
<td>2nd Inpatient Encounter (Transfer or Readmission)</td>
<td>117 (23.8%)</td>
</tr>
<tr>
<td>3rd Inpatient Encounter (Transfer or Readmission)</td>
<td>54 (11.0%)</td>
</tr>
<tr>
<td>4th Inpatient Encounter (Transfer or Readmission)</td>
<td>30 (6.1%)</td>
</tr>
<tr>
<td>5th Inpatient Encounter (Transfer or Readmission)</td>
<td>19 (3.9%)</td>
</tr>
<tr>
<td>6th Inpatient Encounter (Transfer or Readmission)</td>
<td>14 (2.9%)</td>
</tr>
<tr>
<td>7th Inpatient Encounter (Transfer or Readmission)</td>
<td>8 (1.6%)</td>
</tr>
<tr>
<td>8th through 12th Inpatient Encounter (Transfer or Readmission)</td>
<td>11 (2.2%)</td>
</tr>
</tbody>
</table>

**EVOLUTION OF ISOLATION PRECAUTIONS FINDINGS**

There was an evolution of isolation data specific to Gm (-) MDROs that began with the initial Admission Sequence of patient transfers from LRMC to NNMC that can be traced in Figure 4.0 (page 110). ASC results were reported on 224 (94.9%) of the initial 236 Admission groin culture specimens while 12 (5.1%) individual participants had no ASC done on Admission. Of the ASC Admission cultures, 87 grew Gm (-) organisms of which 16 (18.4%) were also MDRO and needed to remain on isolation (ISO) while the other 71 (81.6%) organisms were not MDRO, therefore not requiring ISO for Gm (-) pathogens. By infection prevention protocol, all initial admissions from LRMC of war-wounded were to be placed on Contact Precautions until their ASC cultures were finalized as not growing pathogens requiring ISO. There were 360 (73.6%) Sequences with patients on ISO and 127 (26.1%) sequences with participants not on ISO. There were 15 of the 16 patients with Gm (-) MDROs who were maintained on isolation
precautions when they transferred to another unit or were readmitted to NNMC after they were discharged. In these cases, the positive culture upon Admission could have served as a quasi-surrogate for the continuing need of isolation. Additionally, of the total number of cases where Gm (-) MDROs were identified by initial Admission ASCs, there were 13 instances where those subjects subsequently obtained at least one additional ASC and there were 3 instances where no subsequent ASCs were ever collected, in which cases there were lost opportunities for CHG bath decolonization protocol implementation.
Admission at NNMC also includes Culture results from LRMC.
RESEARCH QUESTION I:

COMPLIANCE RATE TO IP PROTOCOLS REGARDING ASC, ISO, AND CHG

While there were no ASCs done on admission (including the first two days following admission) to NNMC for 12 patients, ASCs had been obtained at LRMC and were made available to NNMC within 48 hours of transfer to NNMC (data available in Table 4.2, page 112). Of those placed on ISO, 62 remained on isolation through a transfer or readmission. At the time of Admission, 193 (82.1%) were placed on isolation precautions.

Compliance/Noncompliance to Isolation Precautions was documented in 489 sequences throughout the study. There were 301 (61.4%) instances in which patients were recorded as on Isolation Precautions and were in TOTAL COMPLIANCE with the protocol. PARTIAL COMPLIANCE accounted for 59 (12.0%) of patients recorded as being on Isolation Precautions (see Table 4.2). Infection Preventionists were overwhelmingly more likely to be the responsible providers who documented the initiation of Contact Precautions in Essentris®. They were responsible for most of the 334 (90.3%) Progress Notes/Nursing Orders communicating the need for isolation to be started plus 306 (90.5%) Progress Notes/Nursing Orders communicating no further need for isolation. This was in contrast to physicians who were the responsible providers ordering initiation of Contact Precautions 25 (6.8%) times and ordering discontinuation of isolation 22 (6.5%) times in Essentris®.
Documentation of patients receiving any chlorhexidine (CHG) bath occurred in only 181 of the 236 subjects (76.7%). 103 (56.9%) of those CHG baths were in TOTAL COMPLIANCE with an unexpected, unanticipated Pre-op Prep protocol whereby patients would receive CHG bath wipes the evening before surgery and then again the morning preceding surgery. Additionally, 78 (41.3%) of those receiving CHG baths were in PARTIAL COMPLIANCE.

**TABLE 4.2: COMPLIANCE WITH INFECTION PREVENTION INTERVENTIONS**

<table>
<thead>
<tr>
<th>Infection Prevention Intervention</th>
<th>Compliance n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Active Surveillance (Groin) Culture (ASC) Obtained upon Admission (N = 236)</strong></td>
<td></td>
</tr>
<tr>
<td>• Yes</td>
<td>226 (95.8%)</td>
</tr>
<tr>
<td>• No or Documentation Unclear</td>
<td>10 (4.2%)</td>
</tr>
<tr>
<td><strong>Compliance to Isolation Precautions during Sequences of Hospitalization (N = 489 a)</strong></td>
<td></td>
</tr>
<tr>
<td>• Isolated</td>
<td></td>
</tr>
<tr>
<td>o TOTAL COMPLIANCE b</td>
<td>299 (61.1%)</td>
</tr>
<tr>
<td>o PARTIAL COMPLIANCE c</td>
<td>68 (13.9%)</td>
</tr>
<tr>
<td>o NONCOMPLIANCE d</td>
<td>2 (0.4%)</td>
</tr>
<tr>
<td>o NOT ISOLATED / NOT APPLICABLE</td>
<td>120 (24.5%)</td>
</tr>
<tr>
<td><strong>Documentation of Compliance to Chlorhexidine (CHG) Bath Protocol during Any Sequence of Hospitalization (N = 181)</strong></td>
<td></td>
</tr>
<tr>
<td>• TOTAL COMPLIANCE b</td>
<td>103 (56.9%)</td>
</tr>
<tr>
<td>• PARTIAL COMPLIANCE c</td>
<td>78 (43.1%)</td>
</tr>
</tbody>
</table>

a Is the number of events that require the documentation of isolation

b TOTAL COMPLIANCE: the documentation of starting date and ending date, and both were documented by RNs or Physicians.

c PARTIAL COMPLIANCE: lacking 1-3 criteria for Total Compliance, for example, documentation of starting date but no ending date, or vice versa; documented by others than RNs or Physicians.

d NONCOMPLIANCE: neither Start Date nor Stop Date were documented plus neither RN nor Physician documented the need for Isolation Precautions or CHG bath to be initiated or discontinued.
A.  ACTIVE SURVEILLANCE CULTURES

236 (16.3%) of ASC results were documented as relevant to Admission Sequences. Thus, in regression analysis, only those 236 events were included. Of the 236 ASC events required at the time of admission or within the first two days following admission, 226 (95.8%) were fully compliant while 10 (4.2%) were not compliant.

B.  ISOLATION (ISO) PRECAUTIONS COMPLIANCE

There were 362 (74.0%) of the total number of 489 sequences for staff to comply with ISO protocols. Total compliance with isolation precautions was 61.1% (n = 299), and there were very few instances (0.4%, n = 2) of absolute non-compliance for isolation. In regression analysis, total compliance was used as the reference category.

Of additional interest was the number of times per week that war-wounded patients were allowed to leave their ISO rooms to work out in Physical Therapy (PT). This was demonstrated in Essentris®, identifying that the great majority of war-wounded patients on Contact Precautions did not leave their rooms to attend PT (86.0%, n = 203). The most common outings to Physical Therapy occurred once per week for 19 (8.1%) three times per week for 4 (1.7%) war-wounded patients, and five times per week for 2 (0.9%) such patients.

C.  CHLORHEXIDINE GLUCONATE (CHG) BATH ADMINISTRATION

Of the 181 Sequences during which CHG baths were documented as given, documentation in 103 (56.9%) was fully compliant with CHG documentation protocol while 78 (43.1%) were partially compliant. Additionally, 113 (62.4%) of CHG events
occurred as the initial CHG bath while only 68 (37.6%) CHG baths were repeated, with the range of repeated CHG baths 1 – 28. Nurses and infection preventionists recorded CHG baths were initiated (98.3%, n = 178) and stopped (98.9%, n = 177) while physicians ordered 3 (1.7%) initiations and 2 (1.1%) discontinuations. Analysis demonstrated that 31 (17.1%) of patients received a total of one CHG bath, with 69 (38.1%) receiving two CHG baths. 57 (31.4%) of patients received a total of between three and six CHG baths.

**RESEARCH QUESTION II:**

**FACTORS ASSOCIATED WITH COMPLIANCE WITH ASC PROCEDURE**

Since the proportion of compliance to ASC was high and there was a lack of variance for this variable, no hypothesis testing analysis was performed on this variable.
RESEARCH QUESTION III:

PATIENT FACTORS ASSOCIATED WITH COMPLIANCE TO ISOLATION PROCEDURE

Examination of “Injury Pattern” Code identified a large amount of missing data (58.1%, n = 284). A bivariate cross-tab association was performed utilizing “Injury Pattern” Code Solitary Injury vs. Multiple Injury wound categories and ISO compliance that found no significant correlation ($\chi^2 = 0.0, df=1, p = 0.99$). As a result, wound site was not used in logistic regression.

Logistic regression identified that the overall model was not significant ($\chi^2 = 3.70, df = 5, p = 0.59$).

**TABLE 4.3: LOGISTIC REGRESSION FOR ISO COMPLIANCE (n=286)**

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>Significance</th>
<th>Odds Ratio</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days of injury upon admission</td>
<td>-0.06</td>
<td>0.14</td>
<td>0.94</td>
<td>0.87-1.02</td>
</tr>
<tr>
<td>Severity of injury</td>
<td>-0.28</td>
<td>0.18</td>
<td>0.76</td>
<td>0.51-1.13</td>
</tr>
<tr>
<td>SOFA</td>
<td>0.46</td>
<td>0.35</td>
<td>1.58</td>
<td>0.60-4.16</td>
</tr>
<tr>
<td>TBI</td>
<td>0.16</td>
<td>0.71</td>
<td>1.18</td>
<td>0.50-2.78</td>
</tr>
<tr>
<td>Age</td>
<td>0.08</td>
<td>0.81</td>
<td>1.08</td>
<td>0.57-2.08</td>
</tr>
</tbody>
</table>
RESEARCH QUESTION IV:

FACTORS ASSOCIATED WITH CHG BATH COMPLIANCE

A bivariate cross-tab association was performed utilizing “Injury Pattern” Code Solitary Injury vs. Multiple Injury wound categories that found no significant correlation ($\chi^2 = 3.8, \text{df} = 1, p = 0.05$). As a result, “Injury Pattern” Code was not used in logistic regression.

Logistic regression utilizing days of injury upon admission to NNMC, initial Injury Severity Score into LRMC, SOFA scores, TBI, and Age were entered into the model simultaneously. Logistic regression identified that the overall model was not significant ($\chi^2 = 10.87, \text{df} = 5, p = 0.05$).

<table>
<thead>
<tr>
<th>TABLE 4.4: LOGISTIC REGRESSION FOR CHG COMPLIANCE (n = 155)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>B</strong></td>
</tr>
<tr>
<td>-------------------------------------------------------------</td>
</tr>
<tr>
<td>Days of injury upon admission</td>
</tr>
<tr>
<td>Severity of Injury</td>
</tr>
<tr>
<td>SOFA</td>
</tr>
<tr>
<td>TBI</td>
</tr>
<tr>
<td>Age</td>
</tr>
</tbody>
</table>
CHAPTER 5: DISCUSSION
CHAPTER 5: DISCUSSION

The purpose of this study were to examine the documented compliance to infection prevention procedures in the electronic medical record (EMR) by healthcare providers caring for war-wounded U.S. service members and assess patient factors that related to compliance. While the protocol identified 599 TIDOS patients admitted to NNMC from LRMC between June 2009 and May 2011, cleaned data for this study were available for manipulation on a total of 236 patients. They were admitted, transferred, and occasionally readmitted a total of 489 times.

Yassi et al. (2007) reported that infection prevention protocols cut across traditional professional boundaries, and their study findings are in concert with compliance to infection prevention protocols that are significantly affected by a healthy organizational culture and a work environment rather than by personnel’s personal beliefs or attitudes. Such an organizational structure should support automated electronic medical record reporting of protocols, making documentation of compliance to infection prevention an integral part of the Essentris® EMR system. Yassi et al. documented the importance of training demonstrating organizational commitment to keeping healthcare workers informed and allowing them to feel confident in their organization’s abilities in managing existing and emerging infection. They concluded that tying infection prevention procedure compliance to environmental factors and organizational
characteristics was essential. Thus, it seems that efforts to promote culture for both patient and healthcare worker safety would be fundamental to training and should be offered to workers, demonstrating an organizational commitment to safety. Such capability should be bundled into the EMR, reflected in the automatic prompts and menu screens/choices programmed into Essentris®.

The most compliant infection prevention protocol was that of obtaining active surveillance cultures within 48 hours of each patient’s initial admission date from LRMC. That was exhibited by the data showing that 98.3% of new admissions had groin cultures obtained by the second day following their admission to NNMC. This positive compliance with basic infection prevention criteria was essential to adapting each patient’s plan of care to evidence-based practice. With the historically high numbers of war-wounded returning to military hospitals in the continental United States (CONUS), they were empirically placed on Contact Precautions for the likelihood of Acinetobacter baumannii and other gram negative pathogens with which they might be already colonized or infected. Efficiency in completion of ASCs helped to ensure that those who were not harboring such epidemiologically important pathogens could be removed from the constraints of physical isolation in a timely manner. This consistent compliance with the stated infection prevention protocol confirmed that the protocol was actually followed.

In keeping with timely application of ASC was documentation of the need for Contact Precautions to be initiated upon arrival, written in an Infection Control Progress Note and also displayed on the Treatment Sheet so that it would be visible to care
providers as they charted on the EMR regarding their appropriate care of each patient. This was validated in the chart reviews, most reliably documented in the Infection Control Progress Note by a nurse or infection preventionist who also ensured that the Treatment Sheet reflected the need for isolation precautions. While there were fewer explicit notes documenting the need to discontinue isolation precautions, the Treatment Sheet consistently showed the date when Contact Precautions were discontinued. When that occurred there were no more initials of nursing personnel confirming adherence to isolation, effectively documenting that the providers were no longer maintaining such patients on isolation precautions. Infection Preventionists were overwhelmingly more likely to be the responsible providers who documented the initiation and then discontinuation of Contact Precautions (90.3%, n = 334 and 90.5%, n = 306). While this was a remarkable accomplishment, evidence-based practices are becoming everyday requirements, especially in an information technology (IT)-savvy medical world. All required infection prevention protocols should be entered into the EMR via consistent orders that trigger automatic menus with drop-down boxes enabling providers to easily and efficiently document their practices. Furthermore, these checklists and documentations of adherence to protocols must be readily queried for reports of compliance/noncompliance in order to provide prompt, transparent information and statistics as feedback to the personnel themselves, administrators, and the patient/family clientele.

The lack of evidence of adherence to CHG baths for war-wounded in the ICU upon arrival and every third day thereafter was disappointing. Administration of CHG
bathing is an important part of staff orientation the Nurse Clinical Specialist provides for nursing staff in the ICU. Despite her efforts, EMR documentation of compliance was only consistently identified by searching the EMR for PreOp Prep notes, then determining if they were signed off as completed by the nurse. As Baddar, Worthing, Al-Rawas, Osman, and Al-Riyami (2006) reported in their study, documentation compliance to patient care protocols should be improved in various healthcare settings. They write that omission of any data points contributes to inappropriate classification of patient severity. They then suggest that computer-based clinical decision-support systems that incorporate forcing functions may improve clinician performance. That is in keeping with the findings of this current study.

**CONCEPTUAL FRAMEWORK SUPPORT**

The conceptual framework providing the basis for this study looked for correlation of healthcare provider compliance to documentation of infection prevention protocols in the electronic medical record with independent variables including individual patient characteristics and injury-related factors.

Monthly patient census on each participating inpatient unit increased throughout the two year period of the study (personal communication, R.F. Weiler, July 27, 2011) adding stress via the numbers of patients to the workload of healthcare providers along with a lack of historical memory in newly hired civilians and contractors employed to cover numbers of critically ill war-wounded. During six months of this same two-year period, the hospital ship *USNS Comfort* experienced two large-scale deployments,
leaving NNMC without a substantial portion of active duty personnel (see Table 5.0, Census of Participating Wards, on next page). At those times NNMC-based active duty officers and enlisted personnel were temporarily re-positioned to staff the hospital ship. All deployed NNMC personnel were replaced as much as was practicable by reservists and temporary contractors while any remaining active duty and civilian personnel expanded their responsibilities to cover the needs of the escalating patient population. The reality in such deployments was that civilians, military reservists, and healthcare contractors stepped in to care for the burgeoning patient census. These resulted in increasing needs for a variety of things such as orientation, assessment of competencies, oversight of personnel not fully versed in seemingly simple things such as the physical layout of the hospital and clinics, strategic phone numbers, functioning of pneumonic tubes for lab specimens, emergency preparedness, evacuation routes, etc.
A major strength of this study is that it expanded the parent TIDOS study previously limited to infectious diseases into infection prevention. This electronic medical record review for confirmation that infection prevention protocol compliance occurred in war-wounded personnel was the first time infection prevention was introduced into the overarching TIDOS project.
LIMITATIONS

A tremendous limitation for this study was that the availability of TIDOS data of all 599 war-wounded transferred from LRMC Level IV care to NNMC Level V definitive acute care and rehabilitation in CONUS was only available for 236 patients. That is short of the suggested minimum sample size of 315, making Type II errors more likely. Another limitation is the lack of organizational data.

IMPLICATIONS FOR NURSING

This study contributes to the body of nursing knowledge, scholarship, research and practice. It was accomplished by making a concerted effort to focus on evidence-based practice in patient care via documentation of infection prevention compliance in the electronic medical record. When compliance is below expected value, interventions should be designed to increase compliance. This study provides baseline data for compliance with the documentation of adherence to infection prevention protocols in the EMR.

FUTURE RECOMMENDATIONS

Replication of this study utilizing the entire data set of 599 war-wounded transferred from LRMC to NNMC would help validate findings of this pilot. Additionally, a comparable could be undertaken at BAMC to further corroborate compliance during the same timeframe at the other Level V military facility in CONUS accepting OIF/OEF traumatic war-wounded patients from LRMC.

Currently the DoD is in the process of standardizing standard clinical content in the EMR, particularly in relation to best practices and evidence-based practice in relation
to documentation of compliance with infection prevention practices related to central line
insertion, indwelling foley catheter maintenance, and ventilator maintenance. This is in
response to the DoD’s contract with the DHHS initiative, Partnership for Patients, to
lower healthcare-associated infections 40% by the end of 2013 using 2010 NHSN data as
the baseline for improvement. Documentation will be both outcome data (infection rates
that include central line-associated bloodstream infection, ventilator-associated
pneumonia, and catheter-associated urinary tract infection) and maintenance/process data
(best practices related to central line insertion, ventilator maintenance, and foley catheter
maintenance). The result of these standardizations will be the capability for Nursing,
Infection Prevention, Medical Staff, Risk Management and Quality Management
personnel to query Essentris® for compliance reports on those practices. Once that is in
place, further validation of compliance to infection prevention protocols documented in
the EMR should become readily available. This is imperative so that hospitals and
systems can more easily comply with ever-increasing demands to provide transparency
and lower healthcare-associated infections to zero.

**CONCLUSION**

This pilot study highlights the weakness in electronic recording when it lacks a
systematic structure designed to ensure that daily bedside infection prevention protocols
are carried out. Healthcare personnel charting in the EMR has not kept pace with the
capabilities of 21st century information technology. The study demonstrates a lack of
evidence of compliance practices that is contrary to bedside and clinical specialist
personnel’s verbal reporting of adherence to infection prevention protocols related to
isolation, repetitive ASCs, and CHG baths. There must be a systematic organization of Essentris\textsuperscript{®} order sheets, progress notes, and treatment sheets to trigger automatic dropdown menu boxes and checklists for compliance with the documentation of adherence to infection prevention protocols. Evidence-based practices must be documented via a thoughtfully engineered EMR of systematically designed systems i.e. menu boxes and checklists to be truly visible and quantifiable. Infection preventionist must be able to query the EMR for reports related to infection prevention protocol compliance. Bedside nurses must be supported via consistently engineered documentation that can also be supplemented by traditional freestyle notes so that true transparency of care/adherence to protocols is visible and measurable. Free text fields should continue to be available for all patient records, for enrichment of programmed records via unique assessment descriptions.
APPENDIX A: USUHS IRB APPROVAL IDCRP-024
APPENDIX B: GMU HSRB NOTIFICATION

TO: Qiuping Zhou, College of Health and Human Service
FROM: Keith R. Bunhey, Chief of Staff, Office of Research
DATE: November 16, 2011
TITLE: Healthcare Personnel Compliance with Infection Prevention Protocols in U.S. War Wounded

PROTOCOL NO: 7803

Cc: Judith English, College of Health and Human Service

The Office of Research Subject Protections has reviewed your human subjects research review application and found that there is no need for the Human Subjects Review Board (HSRB) to review the work. The federal regulations do not require the HSRB to review the study since you will not be gathering information about any individual human subject. As such, no further action is required of you at this time to comply with the GMU human subjects policy. However, if you modify your project to include human subjects research activities, you are required to request and receive approval from the human subjects review board prior to conducting the research activities.

You may contact me at 703-993-3088 if you have any questions or need clarification. Thank you for your patience while the Office of Research Subject Protections reviewed your paperwork to make this determination.
REFERENCES
REFERENCES


CURRICULUM VITAE

Judith English is a registered nurse, currently the Infection Control Consultant for the U.S. Navy Bureau of Medicine and Surgery. She received her Master of Science in Nursing from George Mason University in 1990 and her Bachelor of Science in Nursing from the University of Michigan in 1966. She is Certified in Infection Control and Epidemiology (C.I.C.) by the Certification Board of Infection Control and Epidemiology, Inc., and serves on the Editorial Board of the *American Journal of Infection Control*. Judith is a member of Sigma Theta Tau International Nursing Honor Society, Epsilon Zeta Chapter; a past president and current active member of the national Association for Professionals in Infection Control and Epidemiology, Inc.; and a member of the Society for Healthcare Epidemiology of America. Professional experiences include infection prevention/control, consulting, education, public health, women’s and newborn health, and critical care.