Provably Clean: A Formal Analysis of Hand Hygiene During Anesthesiology Induction

Investigating The Impact Of Environmental Factors On Surgical Infection Rates In The United States

A Thesis Prospectus In STS 4500

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By
Neha Pavuluru

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Technical Team Members: Bella Holloman, Austin Campbell, Gabriel Lawrence, Sergio Darquea, Olivia Claire Rose

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

ADVISORS

Joshua Earle, Department of Engineering and Society
Matthew Bolton, Systems Engineering

Introduction

Infection rates during in-patient services have risen in the United States healthcare system. Surgical site infections (SSIs) are severe complications in about 2% of surgeries in the United States and account for about 20% of healthcare-acquired infections (HAIs) (Johns Hopkins Medicine, 2009). Understanding how SSIs and HAIs are transmitted and possible preventative measures is essential. The most common ways germs can enter a patient's body after surgery are through the touch of a contaminated caregiver/surgical instrument, air, or germs already in or on the body (Smith, 2010). The anesthesiology department is often scrutinized during an HAI event since they operate across various patients and are involved in inserting catheters. To understand the occurrence, progression, and impact of HAIs, it's crucial to model infection rates during surgical procedures. Computational modeling will be used to realize HAIs and propose solutions to minimize the risk of cross-contamination between dirty and clean spaces in the surgery room.

In this prospectus, I will present a technical project, "Clean Your Hands: Using Computational Modeling to Improve Infection Rates in Anesthesia Induction," followed by a STS project, "Investigating The Impact Of Environmental Factors On Surgical Infection Rates In The United States." My technical project involves using a novel computational method to predict infection rates in anesthesia induction. My STS topic involves studying the socio-technical factors that affect a medical practitioner during patient care. The overarching research question is: how do social, technological, and institutional factors influence the practices used by medical professionals to understand and mitigate rising surgical infection rates? This question is important because it considers the various factors that affect the ability to provide safe and clean care, such as technological advances and environmental conditions. The technical and STS

portions are interested in understanding and mitigating HAIs. These sections will be followed by key texts relevant to both topics.

Technical Paper

Hand hygiene during anesthesia induction is an area that is being increasingly researched, especially concerning HAIs. Patients are the most vulnerable during this procedure due to the intimate contact anesthesiologists have with the patient's blood and respiratory systems. If sanitization practices are not adhered to, this can lead to germs entering a patient's body, thus an HAI. HAIs can lead to grave consequences such as sepsis and death (Revelas, 2012). Proper infection control practices are expected to be in place; however, multiple people working concurrently may be challenging (de Lissovoy et al., 2009). Moreover, anesthesia induction is a rapid procedure that may make it difficult for practitioners to sanitize their hands properly or remove gloves between steps (Biddle et al., 2018).

To address this recurring issue, a novel computational method will be used to study the different steps in the induction process and track the transmission of germs. Model checking will be performed to understand whether the proposed model exhibits desirable characteristics and to examine any counterexamples. A deeper analysis will also examine the effect of skipping steps and touching hands during the procedure.

The first step in the technical project is watching videos on anesthesia induction from various medical centers worldwide and those provided by UVA Health. This helps us understand the procedure and accurately model it. The different anesthesiologists and tools used will be noted in a spreadsheet. The tools and the anesthesiologists' hands will be classified as dirty or clean. The spreadsheet will then be translated into Python code as the formal model. The formal

model will then be checked in the PRISM language using two parts. The first part is simply keeping track of the steps in the intubation process. The second part tracks which steps/objects in the intubation process are dirty or clean and what leads to that classification. After the model is translated into the PRISM language, it can be checked against different conditions. The user must specify the conditions to check and address any counterexamples produced. The current model checks whether certain “important” parts of the procedure are dirty or clean at the end of the procedure.

Since our sponsor is UVA Health, anesthesia induction observations will be conducted to modify our model according to UVA-specific anesthesia induction practices.

STS Topic

Research Question

My report's overarching STS research question is: how do social, technological, and institutional factors influence the practices used by medical professionals to understand and mitigate rising surgical infection rates? Up to this point, we have delved into the implications of HAIs and discussed the link between infections and hand hygiene. We’ve also scrutinized the anesthesia induction process and identified its potential to contribute to lapses in safety practices, which may result in HAIs or SSIs. A crucial area that warrants further exploration encompasses the impact of technological innovations, societal practices, and the pressures intrinsic to hospital settings on an anesthesiologist's adherence to safety protocols. My overarching question branches out into several nuanced sub-questions, each of which will be approached using a variety of research methodologies.

The first sub-question is: how have social issues shaped surgical processes? It's important to understand how surgical processes have evolved concerning issues regarding gender, race, and disability. I will examine how surgical techniques have improved to help benefit marginalized communities. To answer this question, I'll also analyze historical case studies on past surgical practices and devices. Furthermore, I will review articles and research reports on current and past innovations and their impact on surgery. This will provide a basis to analyze the change in surgical practices over time and how technology has impacted that.

The second sub-question is: how does the hospital environment affect the practices adopted by medical professionals and their ability to provide quality care? Understanding the environmental and internal elements can affect a medical professional's ability to provide safe and quality care. Oftentimes, there are stressors in a hospital setting that can hinder proper hygiene during surgical procedures. Moreover, the common practice of long shifts and constant understaffing can increase inattention and infection. I will use various methods to answer this question, including analysis of case studies, research reports, and interviews. I will also explore case studies on the impact of poor working conditions and lack of regulation on infection rates. I'll analyze research reports from NIH to study the impact of working conditions on human behavior. Lastly, conversations with professionals from UVA Health will provide insight into their views on SSIs.

The final sub-question is: what practices can be implemented to minimize the risk of infection? It is crucial to understand potential solutions to mitigate SSIs. Examining past practices, their evolution into current practices, and further changes to be made can help mitigate the risk of SSIs. I will conduct literature reviews to understand current practices and

developments in this space. This connects to the technical report and has the potential to be implemented in UVA Health.

Social Groups

The primary relevant social groups for this research question would be medical practitioners, including doctors and nurses, hospital management, and patients. These groups are the ones who are primarily impacted by infection prevention practices. Doctors and nurses are responsible for the patient during surgeries and, thus, are major contributors to SSI risk if proper hygiene practices are not followed. Hospital management is also another relevant social group since they are the ones who will investigate the cause of the SSI and deal with any malpractice lawsuits. Lastly, patients are also a primary social group since SSIs directly affect them, which can lead to complications or death. Other relevant social groups are marginalized communities, women, and disabled people. The medical community has undermined these groups and often has higher postoperative infection rates (Brooks Carthon, Jarrín, Sloane, & Kutney-Lee, 2013; Aghdassi, Schröder, & Gastmeier, 2019).

Secondary relevant social groups include families of the patient and insurance companies since they are indirectly affected by the implications of HAIs. The patient's families must carry the emotional and financial burden of an extended hospital stay. Insurance companies must pay the bulk of the cost of an extended hospital stay.

Framework

Michael Callon's paper, *Some elements of a sociology of translation: domestication of the scallops and the fishermen of St Brieuc Bay*, has been pivotal in shaping the Actor-Network Theory (ANT) (Callon, 1984). ANT provides a framework to explore how actors (both human and non-human) intertwine in various systems. This framework has allowed researchers to dive

deep into networks and understand what drives them, the different stakeholders, and the changes that can occur.

This framework will analyze the social and institutional factors affecting a medical practitioner's ability to provide quality care. In this case, the actors will be the various human and non-human entities that undergo a surgical procedure. These include medical practitioners, the equipment used for the procedure, and rules/regulations. Medical practitioners rely on the equipment they are given, one of which includes advanced sanitization tools. Lack of tools such as a contactless hand sanitizer can increase the risk of infection as it's harder for them to clean their hands between steps. Moreover, understanding the environmental stressors in the hospital as actors will provide a more comprehensive view of what can impact a doctor's performance in the operating room.

These actors will unite to form various networks of what can happen during surgery. An area of interest will be analyzing heterogeneous networks and power dynamics. Understanding the chaos breakdown within these networks and the various power dynamics between actants is crucial. This will provide insight into how the different actors impact infection rates during surgery.

The ANT study will provide a holistic view of factors contributing to SSIs.

Timeline

The timeline of my project will be from now until April 2024. Initial observations will be conducted on November 2nd, 2023, and November 7th, 2023. Subsequent observations will be arranged as necessary throughout January 2024 and April 2024. No research will be conducted during official university breaks. I will analyze literature and documentaries twice weekly

throughout January 2024 and April 2024. I will also conduct informational interviews during the same time either on Zoom or during in-person observations.

Key Texts

The first primary source I examined is *Some elements of a sociology of translation: domestication of the scallops and the fishermen of St Brieuc Bay* by Michael Callon. The paper is crucial to exploring the environmental factors that lead to SSIs because it introduces ANT as a method to describe scientific practices and innovations. The main argument in this source is that complex negotiations between human and non-human actants shape scientific knowledge and techniques. Their interests are aligned in a network and treated as a single entity. Callon introduces five steps in ANT: problematization, interessement, enrolment, mobilization, and irreversibility. These are important in identifying the different actants in the SSI network.

The second primary source I examined is *Health care-associated infections – an overview* by Mainul Haque, Massimo Sartelli, Judy McKimm, and Muhamad Abu Bakar. Published in Dove Press, this source provides an overview of HAIs. It includes the history of HAIs, their impacts on patients/healthcare systems, and guidelines published by the World Health Organization to mitigate rising infection rates. This text provides historical context and past preventative efforts.

The third primary source I examined is *Burnout and Doctors: Prevalence, Prevention and Intervention* by Shailesh Kumar. Published in MDPI, this source outlines the high levels of stress doctors face in their profession and eventual burnout. The main argument of the source is that doctors who are burnt out have a higher risk of making poor decisions, being hostile towards patients, making medical errors, and having complicated relationships with co-workers. This text

is crucial for identifying potential stressors contributing to doctors making medical mistakes that could increase infection rates.

The fourth primary source I examined is *Transmission of Pathogenic Bacterial Organisms in the Anesthesia Work Area* by Randy Loftus, Matthew Koff, Corey Burchman, Joseph Schwartzman, Valerie Thorum, Megan Read, Tammara Wood, and Michael Beach. Published in ASA, this source discusses the transmission of bacteria during anesthesiology procedures. In particular, the study looks at the transmission of hand-mediated bacteria across different surfaces in the operating room. The main argument of the study is that using a random sample of 61 operative suits, they found the transmission of pathogens from contaminated surfaces. This text is important in identifying the role anesthesia plays in HAIs.

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