Thesis Project Portfolio

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

(Technical Report)

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

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

Introduction

Healthcare-acquired infections (HAIs) and surgical site infections (SSIs) are severe complications that occur during medical procedures, such as surgery. They often lengthen the patient's stay and place major financial burdens on the hospital. It's important to understand how SSIs and HAIs are contracted and transmitted. Bacteria can enter a patient's body if the practitioner's hands are infected, a tool is infected, bacteria is already present, or via air.

The anesthesiology department is scrutinized frequently due to the fast-paced nature of anesthesia induction. Since the process is so fast, it becomes hard to follow every step of hand hygiene and label dirty/clean tools accordingly. Moreover, anesthesiologists work across multiple operating rooms, making it difficult to track the transmission of germs.

The technical portion of this portfolio will consist of a formal analysis of hand hygiene during anesthesia induction. A novel computational method was used to model the anesthesia induction process, and a model-checking process was used to identify clean/dirty pieces of equipment during the procedure.

The STS portion of this portfolio will analyze the social, technological, and environmental factors that impact surgical site infections in the United States. The paper analyzed the surgery network using the Actor-Network Theory and various subnetworks. Chaos breakdown among the different networks was explored, and the relationship between the different actors was related to how the patient ultimately gets infected.

Technical Paper

For the technical project in this portfolio, we conducted a formal analysis of hand hygiene during anesthesia induction. The University of Virginia Health was our client, so we formed tailored recommendations for UVA. We used various resources provided by our client to understand the anesthesia induction process better. The first step in starting our technical project was to watch a video created by the University on proper anesthesia induction protocol. We formed a spreadsheet tracking the steps in the process, the equipment used, and who was touching the equipment (practitioner 1 vs practitioner 2). We also conducted physical observations at the UVA Hospital to better understand how real-time anesthesia induction works. We converted this spreadsheet into a formal model and used model-checking software to identify which objects were dirty and clean at the end of the procedure.

The second step in our technical report was analyzing different scenarios that could stem from our base model. This includes skipping one of the cleanse steps and having certain objects dirty at the beginning of the procedure. For each scenario, five iterations were run, with the end state of the objects in the previous iteration being the starting state of the objects in the next iteration. This was to simulate objects not being cleansed properly after each procedure in an operating room. The model-checking software was used to verify the properties of the objects.

We concluded that a dirty tray (an open container used to organize surgical tools) and a dirty Pyxis drawer (a drawer in the Pyxis machine used to store equipment) infected the patient. Thus, it is crucial to maintain the cleanliness of those two objects rather than focusing on hand hygiene.

STS Paper

The STS paper in this portfolio investigates the impact of social, technological, and environmental factors on SSI rates in the United States. As mentioned before, SSIs and HAIs are severe complications that occur during a medical procedure. They often result in increased hospital stay for the patient, financial burden for both the patient and the hospital, or even death. In this paper, I used the Actor-Network Theory (ANT) to analyze the surgery network and the various subnetworks that stem from it. The surgery network has 6 main actors: the surgical theater, medical practitioners, the hospital, the patient, surgical tools, and bacteria. The surgical theater is listed as the central actor in the surgery network since it is a controlled environment.

The five other actors have either subnetworks of their own or crucial relationships with the other actors in the network. The hospital and the medical practitioner subnetworks were explored. The hospital subnetwork consisted of management and lawyers; the primary goal of this network is to reduce financial and legal burdens on the hospital and reinforce safety protocols. The medical practitioner subnetwork included surgeons, certified nurse anesthetists, anesthesiologists, operating room nurses, and surgical technicians. The main goal of this network was to perform the surgery successfully. Bacteria were identified as an antagonists in the surgery network as their main goal is to infect the patient. The medical practitioners must practice proper hand hygiene and disinfect the tools to ensure the patient doesn't contract an SSI. I recommend hospitals strengthen training protocols and make safety guidelines comprehensive.