Thesis Project Portfolio

Neonatal TAPP (Thoracentesis, Abdominal Paracentesis, Pericardiocentesis) Trainer

(Technical Report)

Social and Ethical Implications of Bias in Simulation Based Medical Training Devices

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

Simulation-based medical technologies are playing an increasingly important role in preparing medical professionals for real-world procedures. While these tools offer valuable opportunities for hands-on learning in controlled environments, they also raise several questions about inclusivity and ethical responsibility. My technical capstone focuses on creating a high-fidelity, realistic training manikin for neonatal surgeons within the Neonatal Intensive Care Unit (NICU) at UVA Health's Children's Hospital. My STS research explores the social and ethical implications of simulation-based devices, specifically cardiopulmonary resuscitation (CPR) manikins. Through the use of Social Construction of Technology (SCOT) and Care Ethics frameworks, I analyze how simulation technologies are shaped by different social groups and the moral obligations of these groups. Taken together, these projects offer valuable insights into the practical decision-making that drives engineering design and the broader ethical reflections that emerge when considering how these technologies impact different stakeholder groups.

For my capstone project, I am creating a neonatal manikin that allows surgeons to practice performing thoracentesis, abdominal paracentesis, and pericardiocentesis, procedures used to drain excess fluid from the lungs, abdominal cavity, and heart, respectively. These surgeries are often life-saving procedures performed on neonates, or newborn infants less than four weeks old, who are especially vulnerable. Current methods of training lack anatomical realism, reusability, and ultrasound compatibility, which is an essential feature as these procedures are performed under ultrasound guidance. Our team's manikin addresses these gaps by containing 3D-printed, anatomically correct organs and is constructed using materials that are refillable and simulate the look and feel of neonatal skin and tissues under ultrasound.

Throughout the development process, we have worked closely with the UVA NICU department to ensure the manikin supports practical and accurate training.

In my STS research paper, I demonstrate how, while simulation-based medical training devices improve patient safety, they contribute to unintended ethical consequences when they fail to reflect the diversity of all patients. Using the SCOT framework, I analyze how the different social groups, manufacturers, educators, trainees, policymakers, and patients all shape the design and use of CPR manikins. A key case study by Dr. Rebecca Szabo revealed that the majority of CPR training manikins lacked female anatomical features and thus contributed to worse clinical outcomes for women during cardiac arrest. I also use a care ethics perspective to highlight the moral obligations these social groups have towards patients and trainees. I conclude that an inclusive design in medical simulators is not only a technical challenge but also a moral imperative.

Working on these projects deepened my understanding of medical manikin design. My capstone project helped me realize the real-world trade-offs that arise during engineering development. While my STS research gave me the opportunity to step back and critically reflect on the broader impact of those choices. Taken together, I have learned to approach the engineering design process with practical sensitivity and ethical awareness.