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

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Michael Pandula

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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

Advisor

Kathryn Webb-Destefano, Department of Engineering and Society

Introduction:

Over the past decade, there have been several significant advancements in medical simulation technology that have changed the way clinical training is performed. These technologies have given medical professionals the ability to practice complex procedures in controlled environments, which has drastically improved patient safety (Elendu et al., 2024). However, despite their widespread adoption and clear benefits, this technology also presents a number of ethical issues. While these devices are designed in order to improve patient safety, they contribute to unintended consequences, such as medical professionals overestimating their competence in real-life scenarios as well as inequalities in patient care. One such example of an inequality in patient care is the gender bias present in CPR training manikins, which frequently lack the anatomical representation of female bodies. This paper examines the social and ethical implications of such design flaws.

Medical professionals acknowledge that simulation-based training tools improve patient outcomes by enhancing the ability for trainees to acquire skills and reducing the number of surgical errors. The use of such tools enhances the technical proficiency of the clinicians. Yet, by training solely using these devices, medical professionals may create a false sense of security, which could lead them to believe they are fully prepared for real-world clinical challenges when in fact they may not be. This can result in clinicians being unable to properly carry out the procedures, putting the patient's safety at risk. Medical professionals must learn to recognize the limitations of simulation-based training, because if the simulation itself is flawed, it may fail to adequately prepare clinicians or trainees for real-world procedures and thus compromise patient safety. This paper will explore these ethical implications through the lens of the Social Construction of Technology (SCOT) framework and Care Ethics.

In order to illustrate this analysis with a real-world example, this paper will examine a case study led by Dr. Rebecca Szabo at the Royal Women's Hospital in Melbourne, which found that many CPR manikins lacked representation of female breasts. This design oversight lowered the likelihood of women receiving proper CPR from bystanders, as trainees either felt unprepared for real-world conditions or were simply unable to properly perform CPR. This case underscores how biases in design can reinforce systemic inequalities in patient care. The analysis of this case highlights the need for medical simulation devices to consider both social and ethical aspects in their development and production in order to prevent disparities in medical training and patient care.

Literature Review:

In order to fully understand the ethical implications of the biases and limitations in medical simulation technologies, it is essential to examine existing research that highlights how these issues arise in practice. These studies will set the stage for understanding the broader social and ethical consequences of medical simulation design and how they fail to adequately prepare trainees and perpetuate healthcare disparities.

A recent study conducted by Dr. Rebecca Szabo at the Royal Women's Hospital Melbourne investigated gender representation in cardiopulmonary resuscitation (CPR) training manikins. The study attempted to identify whether CPR training manikins are adequately representing secondary sexual characteristics, such as female breast anatomy. They also analyzed if different manufacturers addressed diversity, equity, and inclusion (DEI) in their corporate policies. In order to do this, the researchers screened the products of nine different CPR manikin manufacturers from around the world. They assessed twenty different CPR manikins for their anatomical realism, explicitly focusing on the gender representation of the manikins. They also

reviewed publicly available information regarding the manufacturers' DEI and sustainability commitments (Szabo et al., 2024).

The study found striking disparities. Out of the twenty CPR manikins examined, over 75% were explicitly identified as male, all featuring a flat, traditionally male-shaped torso. With only one manikin providing an optional breast overlay, and just one other manikin having permanent female anatomical features. In addition, only one manufacturer (Laerdal) explicitly integrated DEI considerations into their publicly available reports (Szabo et al., 2024). These findings have significant implications for patient care. The researchers highlighted previous clinical studies that demonstrate notably and statistically poorer cardiac arrest outcomes for women, linked directly to disparities in receiving CPR from bystanders. For example, one cited study found that women are significantly less likely than men to receive bystander CPR in public settings due to several factors, such as fear of causing harm to the patient, and inadequate training on female anatomy (Perman et al., 2019).

Overall, this study relates to the central ethical concerns addressed in my analyses by demonstrating concretely how implicit biases are embedded within simulation-based technologies and how these exacerbate real-world health inequalities. This study explicitly links manikin design to disparities in CPR performance and thus supports the argument that ethical considerations must play a more central role in medical simulation technology development.

Another study conducted by Dr. Christopher Veigel similarly examined diversity in CPR simulation deficiencies, but with a broader focus on adaptations of manikins used in Basic Life Support (BLS) training. The main goal of the study was to evaluate whether CPR manikins, which are currently being used for layperson BLS training, adequately reflect gender, ethnicity, and body type and how these factors may influence training effectiveness on real-world CPR

outcomes (Veigl et al., 2025). The study screened 2,719 studies from multiple different databases, ultimately including 15 relevant studies that explicitly described adaptations to CPR manikins that were aimed at enhancing diversity.

These studies were categorized into two groups: those that analyzed the effects of physical adaptations to manikins used in in-person CPR training and those that evaluated manikin representations in educational videos and social media platforms. Within these groups, the studies assessed adaptations reflecting gender, racial diversity, and body shape variations such as obesity. The outcomes that were measured included the trainee comfort levels, their willingness to initiate CPR, and the quality of the CPR administered (Veigl et al., 2025). Some key findings of this review indicated that there is a significant underrepresentation of diverse manikins. Only 5% of educational videos portrayed non-white manikins, and merely 1% featured female manikins, which highlights the significant gap in representations. Additionally, the study also highlighted that there was a tangible impact of manikin diversity on the effectiveness of the training. Diverse manikins increased trainee comfort, confidence, and quality care given when performing CPR on individuals with different body types (Veigl et al., 2025).

This study demonstrates concrete evidence of the existing biases in the current design and use of medical simulation manikins. It exposes how limited manikin diversity contributes to poor clinical outcomes and thus reinforces the ethical urgency of adapting simulation-based training. Overall, this study provides a solid foundation for understanding how the design choices for simulation-based medical devices may inadvertently perpetuate healthcare disparities.

The two studies demonstrate how design choices in CPR training manikins can perpetuate biases and disparities in healthcare. To investigate and address the ethical implications, it is necessary to use frameworks that not only examine how these biases arise but

also the moral responsibilities of the stakeholders involved. Therefore, this research will utilize the Social Construction of Technology (SCOT) framework and Care Ethics, which together will provide a comprehensive analytical lens to view the societal factors and ethical responsibilities inherent in simulation-based medical training devices.

Conceptual Framework:

The first framework that will be applied is the Social Construction of Technology (SCOT). Popularized by Trevor Pinch and Wiebe Bijker in the 1980's, SCOT argues that technology is shaped by different social groups rather than simply developing in isolation ("Social Construction of Technology," 2025). It emphasizes that technology is shaped and defined by many different social, cultural, and political factors. It is important to view how different social groups influence the design and adoption of simulation-based medical training devices to better understand the ethical considerations that may arise in their deployment. Examples of different social groups associated with these devices are healthcare professionals, manufacturers, educators, policymakers, and the patients themselves.

In order to properly analyze the ethical implications of simulation-based medical training devices, it is also necessary to apply a Care Ethics framework. Care Ethics is derived from the work of Carol Gilligan in the 1980s and focuses on positive social relationships and the moral responsibilities individuals hold toward one another (van de Poel & Royakkers, 2011). In the realm of medical training, Care Ethics highlights the duty of doctors and medical institutions to ensure that medical training truly serves the well-being of both trainees and patients. There is not a great deal of extensive terminology associated with Care Ethics. A criticism, however, is that it is "philosophically vague" because it focuses on relationships and emotions and does not define specific moral guidelines (van de Poel & Royakkers, 2011). Proponents of Care Ethics argue that

care is an important part of society, and thus it is critical to consider relationships and different roles when evaluating the ethical consideration of actions. Together, the SCOT framework and Care Ethics will allow for the analysis of both how simulation technologies are shaped by societal groups and the ethical responsibility to ensure that these technologies actually improve patient care.

Analysis:

Applying the Social Construction of Technology (SCOT) framework to the case studies by Szabo et al. (2024) and Veigl et al. (2025) demonstrates how the inequalities seen within CPR training manikins are a product of the competing interests of various social groups who are involved in their design, manufacturing, and use of the manikins. SCOT emphasizes that technology does not simply evolve independently but instead is reflected by the stakeholders shaping it.

There are several key social groups involved in the production of and use of CPR training manikins. Some of these groups include medical educators, manikin manufacturers, healthcare providers, policymakers, trainees, and patients (Zabao et al., 2021). Each of these groups plays an important role in influencing the design and adoption of these technologies, with each group prioritizing different values and goals. For example, the manikin manufacturers prioritize cost efficiency and ease of production. As realized by Szabo's analysis, the majority of manufacturers produce predominantly male, lean, white manikins due to standardized manufacturing processes and market preferences. This lack of diversity can also be explained as a cost-saving measure since specialized molds and production processes for anatomically diverse models, such as those that accurately represent female anatomy or multiple ethnicities, are more complex and less economically appealing for widespread distribution.

On the other hand, healthcare educators and trainees make up another key social group whose main priority in the manikins is that they are as realistic as possible and function as effective training (Aggarwal et al., 2010). Veigl et al. (2025) demonstrate how the lack of diverse manikins negatively impacted trainees' confidence, comfort, and performance when they encountered patients in real-world scenarios whose bodies differed significantly from the "standard" male manikins. These limitations in manikin diversity reflect a drastic misalignment between the commercial interests of the manufacturers and the medical educators' need for realistic simulation in order to ensure trainees are properly prepared for real-world scenarios. Educators depend on the availability and the affordability of the manikins and are thus constrained to purchase the manikins that are being made and sold by manufacturers (Bulamba (2022). Because of this, educators often tend to purchase standardized manikins and thus further existing biases.

Patients represent a social group that is indirectly impacted by these technological choices. Both studies demonstrate that the underrepresentation of diverse populations in CPR manikins directly leads to poorer clinical outcomes for certain populations, notably women. Szabo et al. explained how women are significantly less likely to receive lifesaving CPR from bystanders due to discomfort stemming from inadequate training. Similarly, Veigl's review also found that CPR manikin rarely depicted diverse ethnicities and body sizes, which potentially contributed to disparities in CPR performance amongst different populations.

The final social group are the policymakers and healthcare administrators who influence these technologies through creating guidelines and regulations. They are the group that is able to mandate standards for diversity and equity in the development of these devices and thus have the ability to significantly shape the market. (Institute of Medicine [US] Committee on

Technological Innovation in Medicine, 1991). However, as Szabo states, only one manufacturer explicitly incorporates diversity considerations into their corporate policies. The absence of widespread regulatory incentives makes it so that manufacturers have little motivation to diversify their product lines.

The interplay amongst these social groups—manufacturers driven by cost incentives, educators focused on effectiveness, patients who need equitable representation, and policymakers with the power to enforce standards—results in CPR training devices that fail to adequately reflect the diversity of the populations that they were created to serve. SCOT's focus on these social interactions demonstrates how these biases in the CPR manikin design process are not just oversights, but outcomes shaped by different social interests. Thus, applying the SCOT framework to these case studies reveals that addressing these ethical concerns around CPR simulation requires more than just technical innovation. It is necessary that there are collaborations amongst these social groups to explicitly align these technological designs with the ethical goals of equity and patient care.

Applying the Care Ethics framework to the two studies allows for an ethical evaluation focused specifically on the relational responsibilities of the medical educators and the healthcare institutions hold towards their patients and trainees. Care Ethics emphasizes relationships and the moral obligations groups have to protect the well-being of others.

Care Ethics emphasizes the responsibility of the healthcare educators and manikin designers and manufacturers to ensure the manikins serve the interests of both the trainees and the diverse populations of patients that they treat. The case study conducted by Szabo et al. showed that there was significant neglect in the female anatomical representation in CPR manikins, which directly led to worse clinical outcomes for female patients experiencing cardiac

arrest. From a Care Ethics perspective, this represents a moral failure by the manikin manufacturers to fulfill their duty of care. This is not merely a design flaw but instead indicates an ethical lapse where the health needs of women are not being acknowledged. The ethical obligation of care demands that there is a recognition and an attempt to rectify these disparities in order to prevent harm and ensure equitable treatment for all patients.

In Viegl et al.'s case study, the results similarly illustrate the ethical implications of neglecting diverse representations of body types in CPR training. According to Care Ethics, CPR training providers have an inherent moral responsibility to cultivate competence among trainees. The significant underrepresentation of diverse body types, as found in Viegl's study, creates an ethical concern by contributing to a lack of preparedness in trainees that can directly lead to harm for certain patient populations. Care Ethics also states that healthcare professionals' preparedness is not a technical issue but fundamentally a rational and ethical issue. This communicates a diminished moral responsibility towards particular groups of patients, which in turn violates the principle of equal care.

Care Ethicists would also emphasize the emotional comfort of the trainees, ensuring that simulation-based training should foster an environment of care for both the patients and the trainees themselves. Viegl et al. reported that there were increases in comfort and confidence when trainees interacted with diverse manikins. This was due to the fact that they felt more comfortable that the skills they learned would transfer over to real-world situations. By failing to provide diverse representations, institutions reduce their ability to form effective caregiving relationships with all patients.

The manikin manufacturers also have an ethical obligation grounded in the Care Ethics framework. Although the manufacturer's main focus is on being profitable, Care Ethics frames

their moral responsibility past simply economic considerations. Manufacturers must consider that their product does not perpetuate disparities or cause indirect harm by neglecting different groups of patients, as CPR manikins directly influence life-saving procedures. The minimal integration of equity consideration as indicated in the studies indicates that manufacturers are not properly fulfilling their broader moral duties.

Ultimately, the Care Ethics analysis of these studies reveals that addressing the disparities present in CPR simulation technology requires first acknowledging and then embracing the moral responsibilities towards patients and providers. Educators and manufacturers must intentionally practice empathy in their designs. In so doing, simulation-based medical training devices can improve both trainee readiness and patient outcomes in an equitable fashion.

Conclusion:

In conclusion, this analysis has examined how biases within medical simulation technologies, specifically CPR training manikins produce significant ethical consequences that negatively impact patient care. By analyzing the research conducted by Szabo et al. (2024) and Veigl et al. (2025), it was shown how these types of manikins fail to represent diverse populations properly. These populations include women, racial minorities, and people with varied body shapes. These inadequacies thus contribute to healthcare disparities.

Applying the Social Construction of Technology (SCOT) framework demonstrated how these biases are not merely oversights, but rather deliberate outcomes shaped by the interactions between the multiple different social groups. The manikin manufacturers, who are driven by economic factors, predominantly only produce standardized male manikins. Educators, who are constrained by the market, are thus forced to train students using equipment that does not

properly prepare them for real-world emergency situations. Policymakers contribute to these outcomes as their lack of regulations influences the manufacturers decisions. This analysis proved that medical simulation devices require collaborative actions from all stakeholders involved.

In order to highlight the moral responsibility these stakeholders have, care ethics demonstrates the need to prioritize the well-being of both the patients and the trainees themselves. Care Ethics emphasizes empathy and relational responsibility to prevent harm to vulnerable groups. The neglect of a diverse representation in CPR manikins is an ethical failure by both manufacturers and educators because it perpetuates hesitancy in emergency scenarios and thus harms patient populations that differ from the standard training models. Ensuring that these training devices are inclusive is not just a technical consideration but rather a fundamental ethical imperative.

To ethically design and produce medical simulation technologies, a deliberate effort must be made to align the interests and responsibilities of all the social groups involved. By actively integrating social and ethical considerations, as grounded in both SCOT and Care Ethics, medical simulation devices can significantly improve patient outcomes for all populations.

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