SINGLE-USE SYRINGES: THE GLOBAL IMPACT OF THIS TECHNOLOGY AND WHY IT MAY NOT BE SUITABLE FOR EVERYONE

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By

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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.

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As healthcare evolves around the world, there is an increasing need to improve the quality of life for patients. All procedures are designed to accomplish this, whether it be through sterilization, management of medical waste, or use of disposable technology. However, an issue arises when medical technology does not coincide with human intentions and needs. One such innovation that has had a controversial effect on its users is the disposable syringe. Single-use plastic syringes were initially developed to ensure that transmissible diseases were not spread among patients (Frankel, 2015). In this aspect, they are advantageous as they eliminate the need for sterilization equipment and the worry of improper sterilization techniques. However, in some instances, disposable syringes can have negative impacts. One example is their use in knee arthrocentesis. Knee arthrocentesis is a procedure in which a physician uses a syringe to aspirate excess synovial fluid from a swollen knee joint (Akbarnia, Saber, & Zahn, 2020). To effectively complete this procedure, the physician must operate the syringe with one hand, and use their non-dominant hand to compress, or "milk", the knee (Zuber, 2002). Currently, this task is cumbersome, and the syringe does not support physician comfort or efficiency. The goal of the technical portion of this project is to eliminate physician discomfort through the development of a one-handed knee aspirator device that will attach to the syringe. It will be designed so that the physician can retract the syringe plunger with only one hand, leaving the other hand free to milk and stabilize the knee. Ultimately, this device will improve the physician's comfort as well as ability to aspirate the knee.

Knee arthrocentesis is only one small example of how physicians interact with disposable syringes. To fully understand the impact of this medical technology, this research will explore single-use syringes in multiple contexts. While the risk of cross contamination has significantly decreased with their use, disposable syringes can pose safety, environmental, and financial

concerns to its users. Disposable syringes require waste management protocols that lead to additional technology and training of healthcare workers (Overstreet, 2018). Developing countries often lack the financial resources to accommodate for biohazardous waste (Battersby, Fielder, & Nelson, 1999). Thus, ethical issues arise as safe access to this technology is not widespread. Tightly coupled with the technical project, the STS research aims to explore the impact of disposable syringes among different social groups. First, risk factors associated with the use of disposable syringes will be broadly discussed. Then, using Actor Network Theory, these threats will be identified in the context of the actors and actants that are affected by this technology (Law & Callon, 1988). A case study will be examined to compare how the network differs based on a country's income status. Overall, this research hopes to answer the following question: how does the use of single-use plastic syringes differ between developed and developing countries, and what are the associated risk factors? Answering this question will establish a more cohesive understanding of this technology and ultimately, support safer medical practices in the future.

RISKS OF DISPOSABLE SYRINGES

No technology can be created without consequences, and disposable syringes are no exception. They were developed in response to an issue of sterilization of medical technology; however, disposable syringes fail to address all of the complexities of the problem. If used properly, single-use plastic syringes effectively eliminate cross-contamination between patients, yet the way individuals interact with this technology may introduce new harm. According to Martin and Schinzinger (2010), engineers have a moral responsibility to promote public safety and welfare through the technology they develop. Engineers must not only evaluate the safety and efficacy of the technology, but also consider the potential downstream effects and harm caused upon device failure or misuse. The aim of this research is to act as an ethical evaluation of disposable syringes through an Actor Network Theory (ANT) framework (Law & Callon, 1988). The ANT allows for greater understanding of a technology through analysis of the human and non-human actors that interact with it. First, the potential risk factors of using disposable syringes will be identified under the categories of safety, environmental, and financial factors as seen in Figure 1 on the following page. Then, this research will explore the disposable syringe network, and review a case study of how certain social groups are affected in different locations. The findings of this research will be published in a cause-and-effect paper. More specifically, this paper will explore the driving factors behind the use of disposable syringes and how these implications impact the entire network.

Safety Factors

Disposable syringes came into use in order to lower cross-contamination and infection between patients; thus, they became a safer option than their glass and metal counterparts (Brusco, 2018). However, single-use plastic syringes did not completely eliminate this problem.

Figure 1: The Risk Factors of using Disposable Syringes: Single-use plastic syringes can lead to potential threats that can be categorized as safety factors, environmental factors, and financial factors (Created by Woessner, 2021).

According to the World Health Organization (2016), the overuse and reuse of syringes and needles caused 1.67 million Hepatitis B infections and 33,877 HIV infections in 2014. The risk of infection is still so high likely due to a lack of adherence to guidelines and a lack of access to medical resources. More specifically, healthcare facilities may struggle to access a sufficient supply of disposable syringes and lack proper waste management resources. Disposable syringes are a biohazard, and require special infrastructure in order to be disposed of properly (Ezeanolue, Harriman, Hunter, Kroger, & Pellegrini, 2017). First, plastic syringes and needles must be collected in labeled sharps containers. These containers must have solid walls to avoid puncture wounds and leakage (Vanderbilt University Medical Center, 2021). Biohazard containers must then be sent off for treatment and proper disposal. The treatment step is especially important, because it diminishes biohazard risk to individuals as well as the environment.

Low-income areas often lack the proper infrastructure to safely dispose of biohazards (Battersby, Fielder, & Nelson, 1999). Improper disposal places sharps in regular waste systems, which introduces the potential of injury to workers responsible for disposing medical trash. Alternatively, countries that lack biomedical waste management systems may try to disinfect disposable syringes. In one case study in New Delhi, it was found that "60 per cent [of syringes] are washed, packed, and resold" (Jamwal, 2015, para. 5). Plastic syringes were not designed to be sterilized, making this practice dangerous. If plastic syringes are simply washed, biologics and bacteria may still be present and introduce a high risk of infection to the next patient the device is used on. Furthermore, these contaminants may pollute the vial in which medicine is being drawn from, introducing risk to many more patients even if a sterile syringe is used (Vieira, 2014). Though this negligence is not as common in developed countries, safety concerns still pose a threat to this group. According to the CDC (2003), sharps "pose the greatest risk for injuries" for healthcare workers if improperly handled ("Treatment of Regulated Medical Waste," para. 6). Developed countries often have suitable access to medical resources and biohazard waste systems; thus, sharps injuries are likely a result of carelessness or improper training.

Environmental Factors

The prevalence of disposable devices leads to copious amounts of medical waste. The World Health Organization (2018) estimates that 16 billion injections are delivered each year around the world. This estimate fails to include disposable syringes used for aspiration purposes, as well as for self-injection at home (Markley, 2020). The trend toward using single-use devices is still growing; however, Glauser, Petch, & Pendharkar (2016) advise that this trend cannot continue due to the devastating environmental impact. Excess waste and improper waste management can lead to air and water pollution, which hurts local ecosystems (Zafar, 2020). One

may presume that larger healthcare facilities are solely responsible for producing excess medical waste. However, size of infrastructure is not the only factor. Cultural values influence individual behavior. In developed countries, individuals generally value convenience and safety of the patient rather than the environmental impact, so disposables are preferred in this context. This value is likely due to the fact that developed countries have plentiful access to resources and large waste management systems. Low-income countries, on the other hand, do not have the same access to medical resources, and as a result, tend to be less wasteful. These areas suffer from shortages of syringes and needles, creating a dual problem of adhering to biohazard waste guidelines while still maintaining necessary supplies (Battersby et al., 1999). The resulting effect is incineration of healthcare waste (Zafar, 2020). Often times, this practice leads to the release of harmful dioxins and heavy metals into the air, which can be dangerous to the local population. Because of these dangers, several countries prohibit incineration of medical waste (Zafar, 2020). Despite geographic location, the introduction of single-use medical devices shows potential for devastating environmental harm. Whether it be through a surplus of waste or absence of infrastructure, the environmental impact of using disposable syringes must be mitigated worldwide.

Financial Factors

The most complicated topic regarding disposable devices is their cost-efficiency. When deciding which devices to use, hospitals are largely influenced by cost (Ventola, 2008). Glauser et al. (2016) claim that one of the reasons disposables are so attractive for hospitals is due to their low upfront costs. Although this blog post provides no quantitative evidence to support this statement, their claims can be backed by data from a study conducted by Silva, Zumpe, Lespinasse, & Aulois-Griot (2018). Data was obtained from a French teaching hospital that used

both disposable and reusable syringe tips. Researchers noted that disposable syringe tips were 23 cents per unit, whereas their reusable equivalents were 51 cents per unit.

While it may be true that disposables are cost-efficient at their initial purchase, the large amount of waste they produce does not come without a price. Vaccari, Tudor, & Perteghella (2018) found that increased medical waste is directly associated with increased healthcare spending. For example, in 2014, the U.S. produced 2.79 kg/bed per day of hazardous medical waste and had a health expenditure per capita of roughly $9,340. In contrast, Vietnam only produced 0.3 kg/bed per day and had a health expenditure per capita of $146. Vaccari et al. (2018) also identified that disposal of hazardous medical waste is associated with a much higher cost than that of non-hazardous waste. Some countries will not be able to handle this financial burden. In this case, low-income countries may prefer reusable syringes, as the "unit cost per injection administered is so much lower" (Battersby et al., 1999, p. 815). Another factor that affects the cost comparison between disposables and reusables is the frequency of which reusable syringes are sterilized. One study found that with daily sterilization, the cost of using reusable syringes was much greater than disposable syringes. However, if only sterilized weekly, the cost of reusable syringes is not far above that of disposable syringes (Silva et al., 2018). Ultimately, the debate on how cost-efficient disposable syringes are depends greatly on the sterilization practices and availability of resources of a given healthcare facility. Thus, generalizations cannot be made in this context.

ANALYSIS OF THE DISPOSABLE SYRINGE NETWORK

Disposable syringes and needles are used globally. However, the implications of these devices vary from location to location, as discussed in the preceding sections. Certain countries suffer from medical resource shortages, others lack biohazard infrastructure, and some areas

simply cannot afford to use single-use devices. These discrepancies occur because different social groups have different needs and therefore, one solution cannot be the same for every group. Specifically, it appears that there is a direct correlation between level of risk and economic standing of a given area. The main risk factors of disposable syringes are broadly listed above, but to explore this hypothesis, ANT will be used (Law & Callon, 1988).

Developed by Law and Callon (1988), the ANT is an analytical method used to understand the relationship between a technology and the human and non-human entities that interact with it (Johnson, 2005). Further, this method seeks to comprehend the technical and social aspects of a technology, and how these aspects are intertwined. By mapping out the human actors and the non-human actants, the influence they have on one another and the relationships between them can help to identify the true impact of a given technology. According to actor-network theorists, social factors are "never an explanation but instead [are] that which must be explained" (Crawford, 2020, n.p.). Applied in this context, in order to understand the implications behind disposable syringes, the social environment in which they are used must be investigated. Figure 2 on the following page illustrates the network that will be studied for disposable syringes. The human actors in this network include healthcare workers and patients. The non-human actors include waste management and education. The next few sections will discuss how users interact with disposable syringes, and how disposable syringes impose risk back onto its users. This analysis also aims to identify relationships among social groups, and how these influences may explain the risk factors identified in the preceding sections. The goal

of this analysis is to address the controversy of disposables and answer the question as to why different social groups use them.

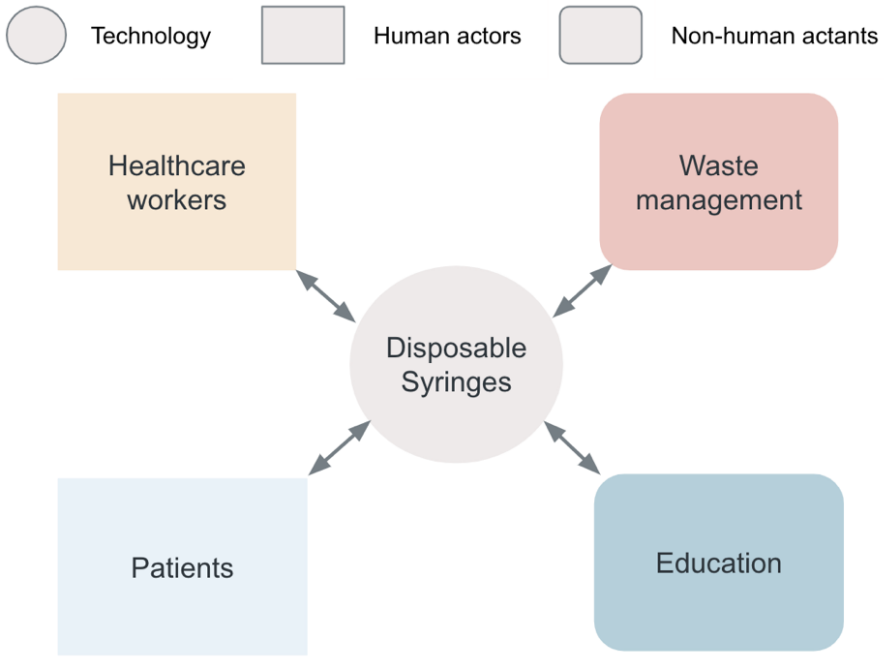

Figure 2: The Network affected by Disposable Syringes: Healthcare workers and patients are the actors that interact with disposable syringes. Waste management and education represents the actants in this network. The arrows go both directions, indicating that this relationship is not one-way (Created by Woessner, 2021).

CASE STUDY: UNITED STATES VS. NIGERIA

Law and Callon (1988) introduce the concepts of global and local networks. Global networks encompass all actors that interact with a certain technology, whereas local networks only encompass a subset of these actors. Since it appears that disposable syringes impose a varying degree of risk on different social groups, this research will study two local networks: the U.S. and Nigeria. The U.S. will represent the use of disposable syringes in developed countries, and Nigeria will serve to provide the same information for third world countries. Then, the two networks will be compared to understand how the relationships among groups impact the risk of

using disposable syringes. The following subsections aim to analyze single-use syringes in the context of each social group and non-human factor for the U.S. and Nigeria.

Healthcare workers

Healthcare workers directly interact with disposable syringes; thus, they may be more impacted by this technology than other social groups. These individuals are responsible for obtaining the proper training on how to follow certain medical procedures involving disposable syringes as well as understanding how to dispose of these biohazards. Lack of training can lead to increased risk of a sharps injury, which directly puts the healthcare worker at risk of infection. In Nigeria, healthcare workers are at a high risk of contracting HIV through needle stick injuries in HIV clinics (Akpuh et al., 2020). This result stems from a twofold problem. Nigerian healthcare workers often lack proper personal protective equipment (PPE), and do not use it when available. PPE is essential in a medical setting, as it "acts as a barrier between infectious materials…and your skin, mouth, nose, or eyes" (FDA, 2020, para. 2). Without it, the risk of infection greatly increases. U.S. healthcare workers are also at risk for needle stick injuries, but this risk is much lower. U.S. healthcare workers generally have access to PPE. Even during the Ebola virus outbreak in 2014, the CDC (2016) reported that distributors were able to provide a sufficient supply of PPE to the majority of healthcare facilities that placed orders. There is also extensive training for U.S. medical workers and oversight from people of higher status. This level of organization in healthcare facilities helps maintain a safe working environment.

Healthcare workers also have an advantageous relationship with single-use syringes. Because they cannot be sterilized, there is no need for healthcare workers to learn sterilization techniques, which eliminates the fear of using a non-sterile device on a patient. Using simple technology can be appreciated by healthcare workers in the U.S. and in Nigeria. Working with

easy-to-use medical devices can allow for more attention to the patient, and less concern about the technology.

Patients

Disposable syringes place the highest risk on patients, who are vulnerable to the malpractices of their physician. Patients cannot choose what medical equipment will be used on them, or have the knowledge that the medical devices are sterile. While a lack of patient autonomy is not necessarily harmful, it does require patients to completely rely on their physicians to promote their wellbeing and make sound decisions. As discussed above, physician malpractice appears to be more prevalent in Nigeria than in the U.S., so these patients may be at higher risk of infection through improper reuse of medical devices (Akpuh et al., 2020).

Another determinant of patient wellbeing is patient-physician relationships. Although medical advancements largely impact patient treatment, patient-physician relationships are still described as "a keystone in the quality of healthcare" (Iloh et al., 2019, p. 87). How are these relationships characterized? While it may be difficult for an outsider to understand the nature of patient-doctor relationships, one study in Nigeria by Iloh et al. (2019) attempted to quantify key characteristics. Certain factors they measured included the degree of patient-centered care or physician-centered care, and inhibitors of patient-doctor relationships. Iloh et al. (2019) found that medical practices in Nigeria were mostly focused on the doctor rather than the patient. However, the researchers also noted that facilities that have been providing care for 10 or more years show significantly greater focus on patients and provide better care than those practicing for less than 10 years. Thus, physicians appear to improve their level of care over time. While this information does not directly apply to disposable syringes, gaining an understanding of how physicians interact with their patients will help illustrate patient wellbeing. One could speculate

that patients receiving care from the patient-centered clinics were at a lower risk of infection from improper sterilization than those at the doctor-centered clinic.

Unfortunately, this same study was not conducted in U.S. healthcare facilities. The American Medical Association (n.d.) presents extensive guidelines for managing patient-doctor relationships that focus on communication and respect for patients when care is being administered. However, further information needs to be obtained on how well these guidelines are distributed and adhered to.

Medical waste management

Single-use syringes indirectly impact the local community through their disposal. The effect is based on several factors, including the amount of waste a country produces, existence of waste management protocols, and adherence to waste management protocols. If waste management systems are poorly managed, the general public may suffer through health and environmental effects. Health effects include infection and chemical or radiation exposure (Macaulay & Odiase, 2016). The U.S. produces more medical waste than Nigeria, nearing 6 million tons of waste each year (Overstreet, 2018). To compare, U.S. healthcare facilities produce 2.79 kg/bed per day of hazardous healthcare waste, whereas Nigeria healthcare facilities only produce 0.28 kg per day (Vaccari et al., 2018; Macaulay & Odiase, 2016). It is important to note that the value for Nigerian facilities is for the overall clinic, not per bed. Therefore, the U.S.'s hazardous waste production is significantly higher than Nigeria's. This is no surprise since U.S. healthcare facilities are much larger, and reuse of disposable syringes is much more common in Nigeria (Eke, 2015). On the other hand, Nigerian healthcare facilities have much lower compliance to waste management systems (Oyekale & Oyekale, 2017). Macaulay & Odiase (2016) identify common waste management malpractices in 10 Nigerian hospitals.

Researchers found that facilities frequently mix biohazard waste with municipal waste or do not treat biohazard waste before disposal. Furthermore, the study found that 6 out of 10 hospitals stored medical waste for an appropriate amount of time, which is a necessary step to reduce environmental threats. However, “only 2 out of the 6 stored it securely” (p. 113). Neglecting to securely store medical waste further increases the risk of injury to waste handlers and the risk of a negative environmental impact. Malpractice in Nigeria is likely based on several factors, including lack of financial resources, improper training, and negligence.

Another discrepancy between healthcare waste management in the U.S. and Nigeria is the existence of waste management protocols. The U.S. has detailed plans on how to manage waste. One example is the Medical Waste Tracking Act that was passed in the 1980s, which provides clear guidelines on what constitutes medical waste, and how facilities should dispose of it (Overstreet, 2018). Nigeria has no equivalent legislation. Medical waste management is seemingly a lower priority than in the U.S. (Macaulay & Odiase, 2016). Nigeria did adopt the WHO guidelines for medical waste management in 2007, but only federally owned facilities actually adhere to them, leaving a large number of private centers that continue to neglect procedures. The U.S. also provides regulations for medical waste incineration. The EPA (n.d.) lays out emission standards to reduce air pollution, which helps mitigate environmental damage.

Despite the extensive regulations, the U.S. still has room to grow in terms of managing medical waste. The sheer amount of medical waste the U.S. produces makes it impossible to avoid environmental damage. The U.S. may want to consider adopting more environmentally friendly technology or modifying waste management infrastructure. Though by different means, both countries put local communities and the environment at risk through disposal practices of single-use syringes.

Education

Education plays an essential role in human behavior. Differences in the medical education between the U.S. and Nigeria give insight into why their medical practices are so different. In Nigeria, medical education suffers from a lack of funding and low standards. One study investigated the perception of Nigerian medical education from the students themselves (Awire & Okumagba, 2020). Medical students expressed sentiments of dissatisfaction and frustration with their educators and medical training facilities. Education facilities also appeared to be in poor condition. Medical technology frequently malfunctions and is not replaced quickly. U.S. medical education, on the other hand, has access to high quality resources and a high standard of medical curriculum. Research plays a critical role at U.S. medical institutions. These facilities give students access to more research and technology, and generate funding for the school (Vioreanu, 2021). Additionally, in 2016, "ninety-six percent of [U.S. medical] students…passed the U.S. Medical Licensing Examination on the first try," which is another indicator of high-quality education (Olds, 2018, para. 9).

Najem & Okuzu (1998) conducted a study between medical students in the U.S. and Nigeria to survey their knowledge of HIV infections and AIDS. This study is important for this research, since one mode of disease transmission is through unsterile needles and syringes. In the U.S., medical students showed greater concern and caution regarding AIDS and HIV infection, despite lower risk of infection of these diseases (Najem & Okuzu, 1998). Nigerian students showed much less concern, and participate in more risk-taking activities. The researchers could not conclude if this discrepancy was due to a cultural difference or lack of education. Altogether, education presents a powerful area of improvement of interactions between people and medical technology. Increased understanding of how technology works, sterilization practices, and

disease transmission will ultimately encourage safer medical practices and promote adherence to regulations.

SUMMARY OF CASE ANALYSIS

Based on the findings from the case study, the local disposable syringe networks for the U.S. and Nigeria were mapped out in Figure 3. The dashed arrows indicate relationships in the network that are insufficient with regards to promoting safe use of disposable syringes. Nigeria appeared to suffer more in all aspects of the network than did the U.S. Nigerian healthcare facilities lack medical and financial resources, resulting in inadequate medical waste infrastructure and waste management training. Because of the inadequacies of Nigeria's medical waste management systems, the local community is negatively impacted through pollution,

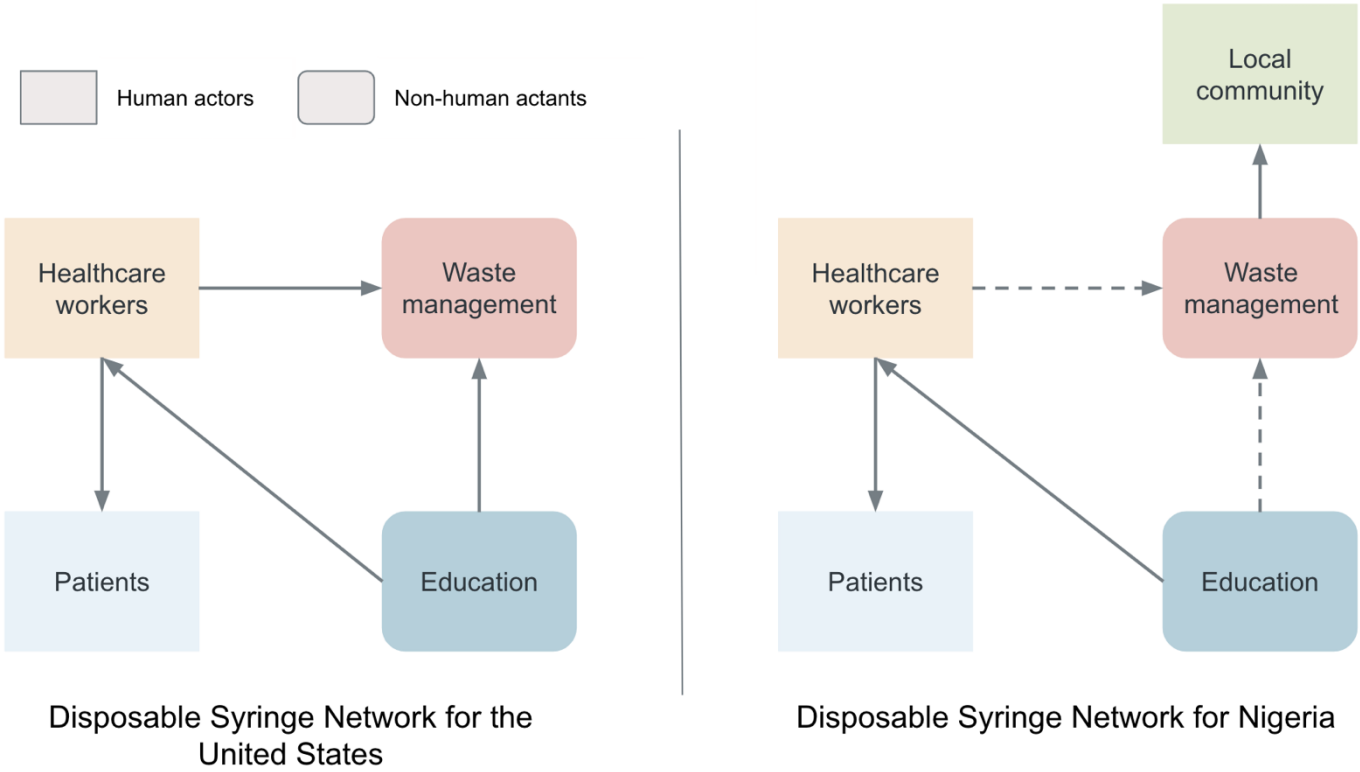

Figure 3: Comparison of the Local Networks affected by Disposable Syringes: The disposable syringe network for the United States represents cohesive relationships among groups. The network for Nigeria displays more broken connections, as noted by the dashed arrows. (Created by Woessner, 2021).

resulting in the addition of the local community to Nigeria's network shown in Figure 3. Nigerian healthcare workers appeared to be much more negligent than U.S. physicians with respect to proper care of disposable syringes. Data from Nigeria also showed a general lack of awareness of the dangers of hazardous medical waste and disease transmission, which further led to misuse of single-use technology.

The discrepancies between the networks for the U.S. and Nigeria can be explained by several reasons. The U.S. has increased access to medical resources and sufficient infrastructure to properly treat and dispose of biohazardous waste. In addition, the U.S. is of higher economic standing than Nigeria, which allows for more funding to contribute to better safety protocols, increased public awareness, as well as higher quality education. Ultimately, this analysis indicates that the use of disposable syringes is more practical and more beneficial to the U.S.

Using ANT is not only useful for recognizing where technology fails, but also can be used to identify potential solutions. The research indicates that there are clear problems with Nigerian physician's adherence to protocols. One way to improve their conduct is by improving the quality of medical education. By enhancing education on the spread of transmissible disease, proper treatment of disposable waste, as well as the detrimental effects of misusing single-use syringes, the connections between healthcare workers, waste management, and education would all be strengthened. Another potential solution is increased government involvement. Unlike the U.S., Nigeria does not have national medical waste management legislation. If medical waste management was standardized and supervised, healthcare workers will be more likely to safely dispose of single-use syringes rather than reuse them. Obviously, Nigeria's lack of financial and medical resources is a large barrier to safe use of disposable syringes. While these solutions can potentially enhance connections within their local disposable syringe network, further analysis

would need to be done in order to ensure that these notions are feasible and will not cause unintended economic burden.

IS THE USE OF DISPOSABLE SYRINGES ETHICAL?

The ANT framework has identified major risk factors associated with the use of disposable syringes. A follow-up question to this research should ask: is the use of disposable syringes ethical? Clearly, the answer to this question varies from location to location. Unethical behavior in healthcare is dangerous, and can harm patients, doctors, and the environment. In this aspect, special consideration should be taken when choosing which medical devices to adopt. Awodele, Adewoye, & Oparah (2016) assert that it is "the duty of hospital and healthcare centers to take care of public health issues such as [medical waste]" (para. 3). Lack of adherence to medical waste protocols directly violates this duty and puts public health at risk. Physicians also have a legal duty of care to their patients. If physicians fail to meet a certain standard of care, they may be found guilty of negligence (Davies & Shaul, 2010). One example of breaching this duty is ignoring safety protocols by reusing a disposable device. Collier (2011) state that reusing single-use devices "may not respect a patient's autonomy" (para. 5). In many cases, using disposable syringes in low-income countries leads to improper use or reuse of these devices, making their use unethical.

Disposable syringes may not be practical or ethical to use in certain areas. Other medical devices may be more sustainable for developing countries, like Nigeria, where misuse of disposable syringes is rampant. Battersby et al. (1999) provide an overview of the advantages and disadvantages of alternative technologies, like auto-disable syringes, safety syringes, and sterilizable syringes. Nelson, Sutamo, & Suradana (1999) provide data regarding how autodestruct syringes may be a safer solution in developing countries where sterilization is a

more widespread issue. Overall, medical technology must be evaluated in a local network rather than global network to determine the safest and most appropriate application of use.

PROMOTING ETHICAL PRACTICES FOR THE FUTURE

This research does not aim to provide a solution, but simply to provide a framework through which the risk factors of single-use syringes can be analyzed. To expand this research, this framework can be used to compare other countries as well. Engineers will be able to have a more comprehensive understanding of the impact of single-use syringes, and use this information to improve similar technologies in the future. A similar cultural comparison could be conducted to unveil the complexities of distributing the COVID-19 vaccine. This framework would aim to answer the following questions: How do different countries prioritize groups? What are the conditions of the vaccination sites? How are the empty syringes disposed of? Ultimately, this framework can benefit medical technology by exploring it through an ethical lens.

Human interaction with medical technology is the foundation of providing quality healthcare. Improving physician interactions with disposable syringes can benefit certain procedures, like knee arthrocentesis. Single-use syringes have also had detrimental effects on its users. Physicians are at risk of injury, patients may be susceptible to infection, and the general population may suffer from the environmental effects based on medical waste disposal. Furthermore, lower income countries appear to be more negatively affected than developed countries due to a lack of medical and financial resources. Thus, the idea of ‘one size fits all’ is certainly not true for technology that has such a widespread impact. Some solutions may be to develop more accessible technology, alter medical infrastructure in low-income communities, or foster relations between developed and developing countries. Overall, this research aims to highlight some of the ethical issues surrounding medical devices. By acknowledging device

flaws and malpractice among its users, engineers can become more aware and continue to produce safer and more accessible medical technology in the future.

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