

**Design Optimization of an Ergonomic Lead Garment**

(Technical Paper)

**The Actor Network that Contributed to the Rise of the Opioid Epidemic**

(STS Paper)

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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

## **Introduction**

### *Ergonomic Lead Garments*

A lead garment is protective clothing used by radiographers, surgeons, and medical teams to protect against the side effects of radiation. As surgery is moving towards more minimally invasive procedures, the use of x-rays and need for protective clothing has significantly increased. The lead garment usually consists of one or two pieces which can weigh up to a total of twenty pounds, leading to a significant amount of orthopedic stress on surgeons and medical teams. These health professionals wear these garments from anywhere from four to ten hours a day while performing operations. Although alternatives have been made to the lead garment in the form of protective shields and zero-gravity machines, these alternatives do not allow for free movement as the surgeon is attached to the contraption, have little to no protection around the neck area, and are not easy to maneuver in an operating room. Moreover, the current alternatives do not function well for people of different heights and weights. Health staff experience more low back pain than other occupations (Karahan, Kav, Abbasoglu, & Dogan, 2009) and a significant amount miss work because of this pain (Pelz, 2000). This device along with the fact that these medical teams are on their feet for most of the day causes a significant amount of stress on their shoulders and lower back leading to persistent pain as they progress through their careers. Therefore, the primary goal of this technical project is to design and test a modified lead garment to reduce orthopedic stress on surgeons and medical teams.

### *The Actor-Network that Contributed to the Rise of the Opioid Epidemic*

The opioid epidemic has been one of the most troubling drug epidemics in the twentieth century that has resulted in 28,000 deaths per year (Conrad, 2017). The epidemic affects a wide variety of demographics, including nearly every race and socioeconomic group. Opioids are a

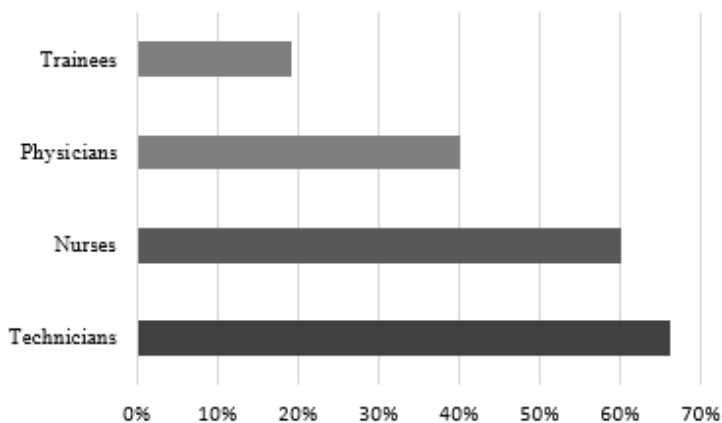
highly addictive class of drugs that are most commonly prescribed to treat chronic and orthopedic pain. The pharmaceutical industry and the healthcare system are structural entities that have significantly impacted the increase in opioid abuse. Unlike other drug epidemics, most opioid abusers have become addicted due to legal, physician-prescribed medications (Trasolini, McKnight, & Dorr, 2018). The over prescription of opioids has led to the drastic increase in opioid abuse in the United States. The structural factors that led to the rise of the opioid epidemic are important to evaluate to be able to modify medical restrictions and healthcare policies to prevent a similar event from recurring. Thus, the primary goal of this STS project is to understand how structural factors in the medical field led to the growth of the opioid epidemic and how that has negatively affected our society.

### **Ergonomic Lead Garments**

The most common practice used by surgeons and medical teams to protect against radiation in an operating room is through the lead garment (Hyun, Kim, Jahng, & Kim, 2016). As surgeries are moving to more minimally invasive methods, the use and requirement of these lead garments has increased (Hamad & Curet, 2010). These garments are highly effective, yet are very heavy, restrict mobility, and do not allow for ease of movement. Thus, there is a need for a development of a new and improved lead garment that reduces the impact of weight, and allows for better mobility. By creating a new lead garment, the orthopedic stress experienced by medical teams will be reduced leading to better performance levels and improved overall health.

Orthopedic and musculoskeletal pain is widely experienced by healthcare personnel due to lead garments. A recent study was conducted to determine the amount of pain experienced by Mayo Clinic employees in the cardiology and radiology departments. As seen in Figure 1, the study concluded that most work-related pain was experienced by technicians (66%), followed by

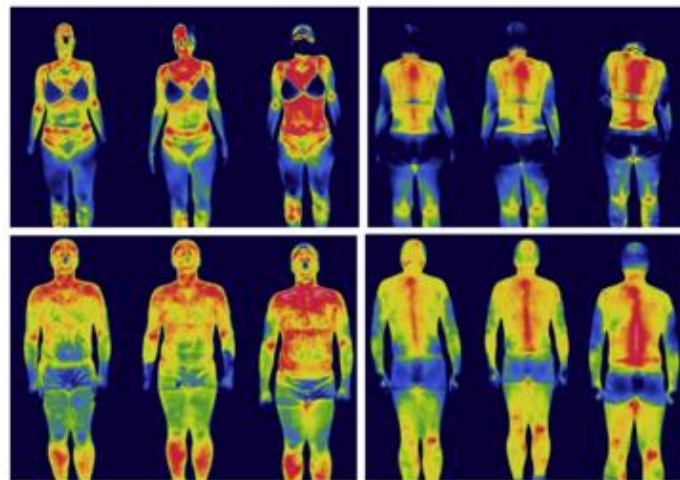
registered nurses (60%), attending physicians (40%), and trainees (19%) (Orme et al., 2015). The study showed that medical personnel who worked in procedures that utilize radiation experienced more work-related pain (54.5%) than their colleagues who did not (44.7%) (Orme et al., 2015). In addition, out of all the employees that were surveyed 30% sought medical care due to work-related pain from lead garments and 16% developed short-term and long-term disabilities (Alexandre, Prieto, Fabien, Taiar, & Polidori, 2016).



*Figure 1. Work-related pain due to lead garments. Work-related musculoskeletal pain among employees involved in procedures utilizing radiation, analyzed by job description (Orme et al., 2015).*

Another study analyzed ergonomic injuries caused by lead garments through infrared thermography (Alexandre et al., 2016). Specific muscle groups were targeted with thermography to determine which muscle groups were affected the most by the weight of the lead garment. The thermography determined that the trunk muscles, which are the pectoral, trapezius, and deltoid, were most affected because they experienced direct contact weight from the lead garment (Alexandre et al., 2016). The thermography also illustrated a spike in temperature surrounding the lumbar spine when wearing the lead garment, which was caused by the over work of the lumbar spine to extend and compensate for the excess weight (Alexandre et al., 2016). Based on the thermography images (Figure 2), there is a significant difference in muscular activity after a three-hour procedure using a lead garment compared to a three-hour procedure without a lead

garment (Alexandre et al., 2016). These results explain why healthcare personnel who work in procedures utilizing lead garments experience on average more occupational pain than those who do not. These studies demonstrate a significant need for a new garment by explaining how current lead garments negatively affect the overall health of healthcare personnel. Therefore, modifications need to be applied to the current design to better the occupational health conditions and increase the longevity for healthcare personnel.



*Figure 2.* Thermography images. Examples of infrared thermographies, at rest (left) and after 3 hours in classical service (center), after 3 hours in the operating room using lead aprons (right) for the two subjects (Alexandre et al., 2016).

### *Timeline*

The primary goal of this project is to design and test a modified lead garment to reduce orthopedic stress on surgeons and medical teams. To start, a three-dimensional miniature human model will be printed to test various lead garment designs. In order to better understand the limitations and challenges of the current design, input will be taken from health care teams at the University of Virginia Hospital. A questionnaire will be used to gather the input from working professionals to determine what they would like to see in the new design. Multiple designs will be created to address the limitations of the current design. Miniature three-dimensional models of the best two designs will be printed and tested on the miniature human model. The distribution of

weight, as well as stiffness and freedom of movement will be measured to select the best option to create a scaled up three-dimensional human prototype. The final lead garment prototype will then be designed to test on medical personnel. The prototype will be tested by allowing volunteer medical personnel wear the lead garment with added weights hanging from the shoulders to simulate the force on the shoulders after about four to ten hours of wearing the garment. The prototype will also be tested by using volunteers to wear the garment while mimicking multiple procedures to determine its comfortability and ability to allow free movement while performing procedures. The prototype should distribute most of the weight towards the hip bones in order to decrease shoulder, neck, and back pain. Each volunteer will be given a questionnaire to rate comfortability, freedom of movement, back pain, neck pain, shoulder pain, and hip pain in order to grade the prototype's effectiveness at decreasing orthopedic stress and its wearability. Depending on feedback from the volunteer questionnaire, the prototype will be adjusted to address the needs of the medical personnel. The final prototype of the redesigned lead garment is expected to be completed by April of 2020.

### **The Actor-Network that Contributed to the Rise of the Opioid Epidemic**

The abuse and misuse of prescription and synthetic opioids have been a national health epidemic throughout the United States. The rise in the opioid epidemic has been attributed to the over prescription of opioids by physicians for pain management (Rothstein, 2017). There have been many social and organizational factors that have contributed to the rise of the opioid epidemic. Physicians, pharmaceutical companies, nurses, and pharmacists have played a significant role in both contributing and mitigating the widespread abuse of opioids. To understand how these differing sectors in the medical field affected the opioid epidemic, it is important to analyze the actor-network that connects these specific relationships.

### *Actor-Network Theory*

Actor-Network Theory (ANT) is a sociotechnical framework that treats social relations of power and organization as a network that affects a central idea (Law, 1992). Actor-network is used to characterize how entities come together and reproduce a pattern of social networks (Law, 1992). ANT has been criticized as a complex theory that is unreliable and unstable because it can be used to interpret a network in many different ways (Cressman, 2009). In order to create a concise analysis of the actor-network that contributed to the opioid epidemic, black-boxing will be used to focus solely on the network of physicians, pharmaceutical companies, nurses, and pharmacists (Cressman, 2009).

### *Application of Actor-Network Theory*

Developing an understanding of the interconnection of the pharmaceutical industry, physicians, and nurses is imperative to reduce the social stigma for opioid abusers and rather focus on the structural factors that contributed to the issue (Kennedy-Hendricks et al., 2017). One of the largest contributors to the opioid epidemic is the pharmaceutical industry. Pharmaceutical companies in the United States focus on a “direct-to-physician” approach for marketing their products (Hadland, Rivera-Aguirre, Marshall, & Cerdá, 2019). Between 2013 and 2015, about one in twelve physicians received opioid-related marketing from pharmaceutical companies (Hadland et al., 2019). Specifically, orthopedic surgeons and physicians are the most likely to prescribed opioid pain medications due to the influence from pharmaceutical companies to “treat pain with pain medication” (Trasolini et al., 2018). The influence of pharmaceutical marketing to physicians emphasized drug therapy for pain management at the beginning of the opioid crisis. The relationship between the pharmaceutical industry and physicians lead to the increased abuse of opioids and mortality rates due to overdoses (Hadland et al., 2019).

Pharmaceutical companies continuously marketed opioids to physicians without initially educating them on the effects of these drugs. Both physicians and nurses were unaware of the effects of opioids because there was no system to educate about the addictive qualities of the drug and how to recognize those warning signs. Physicians were not implementing safe prescribing methods because of the absence of programs to educate specifically on pain management and the suitable opioid prescription use (Hudspeth, 2019). Similarly, nurses lacked education on the opioid epidemic and mitigation efforts in individual State Boards of Nursing (Carlson, Wise, & Gilson, 2019). While education started to develop in the State Boards of Nursing as of 2018, the information was still inconsistent and difficult to locate from state to state (Carlson et al., 2019). The lack of information involving the addictive side effects of opioids from the pharmaceutical industry to physicians and nurses, lead to the unawareness of how opioids would affect public health of many people throughout the nation.

### **Research Question and Methods**

*How did the surrounding actor-network contribute to the rise of the opioid epidemic in the United States?*

The opioid epidemic had many moving parts that affected how opioids became problematic nationwide. To understand how the opioid epidemic affected the United States as a whole it is important to research the actor-network theory and its role in understanding the rise in the opioid epidemic. In order to develop a concise understanding of the actor-network linked to the opioid epidemic it is important to use the method of network analysis. Network analysis is used to describe the organizational structures and hierarchies between multiple factors. This method allows for the understanding of the social and technical networks that create the presence and complexity of relationships. Network analysis will be used to justify how the relationships



between physicians, nurses, pharmaceutical companies, and opioid abusers largely affected the rise of the opioid epidemic.

In addition, to pursue this research question it will be imperative to use a policy analysis to question the formation and implementation of multi-level pharmaceutical and healthcare policies that drove the rise in the opioid epidemic. For this process, the policies put in place at the start of the opioid epidemic will be identified and compared to the recent changes in policies that sought to decrease the abuse of opioids. Lastly, a historical case study of West Virginia, a state largely affected by the opioid epidemic, will be conducted to understand the socioeconomic dynamics that shaped the opioid epidemic. West Virginia is a vital area to investigate because of its high prescribing rates and mortality rates when compared to other states. The high prescribing rates were due to Purdue Pharma, a pharmaceutical company, advertising opioids to physicians in economically small rural areas with many injured and jobless people on disability (Monnat, 2019). West Virginia's socioeconomic status as a whole made it a susceptible area for pharmaceutical companies to take advantage of by heavily marketing opioids.

## **Conclusion**

### *Ergonomic Lead Garments*

This project will advance the technical capability in the healthcare field of surgery by improving the functionality of an important medical device. With the improvement of lead garments, medical personnel will be able to perform operations more effectively as a significant stress factor is reduced. It will allow increased mobility and functionality as the technical capability in clinical practice will also increase significantly. Furthermore, this research will help develop methods and knowledge for future use in improvements of other medical devices causing ergonomic issues. Thus, this project serves as an important resource in the surgical field

especially the emerging minimally invasive field. The expected result of this project is an improved overall health and performance level for medical personnel utilizing lead garments.

*The Actor-Network that Contributed to the Rise of the Opioid Epidemic*

The opioid epidemic shed light on the problematic policies in the pharmaceutical and healthcare industries. These problematic policies lead to a devastating public health problem in the United States. The impact of the pharmaceutical industry's marketing techniques and lack of education on physicians and nurses significantly amplified the abuse of opioids in America. The rise of the opioid epidemic brought a negative connotation towards people who misused opioids, even though most were unaware of the consequences of opioids when they were first prescribed them. Multiple medical sectors and their respective relationships are analyzed in hopes that it will illustrate an emphasis on the structural factors that caused the opioid epidemic and preventative measures needed to avoid a similar event from recurring. This research will help reframe the issue to emphasize the structural factors that led to the opioid epidemic, instead of blaming the individuals who misuse opioids.

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