



« I.C.A, Intelligent Compression Apparatus, An Adaptive Compression Garment Tailored for Nurses »

by

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Submitted in partial fulfillment of the requirements for the degree of

Bachelor of Industrial Design

Faculty of Applied Sciences & Technology
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« How may we improve the well-being of nurses who work in high stress care system? »

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Abstract

« As funding within the health care system continues to decline, nurses working in hospitals continue to be outnumbered by the patients they receive, leading to high patient loads. These high patient loads result in a multitude of negative health effects for the practitioners working these bedside positions. Currently the health of nurses working in the hospital environments are being neglected. An increased amount of stress, fatigue and other detriments quickly add to the decline of the overall health of these nurses. The goal of this thesis proposal is to shift the way of thinking of the current health care system by not only focusing on the patients being treated but also taking into account the health of those providing care. This thesis suggests a complete analysis of daily tasks nurses are exposed to, using a variety of data collection methods such as interviews and surveys, in order to identify common challenges that can be addressed by means of product design. A full-size model will be constructed based on qualitative research in order analyze existing ergonomics and further develop the consideration of full body human interaction. A tangible design solution will be created to benefit the current work-lifestyle of bedside nurses facing high stress situations, further enhancing their overall health. »

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From the bottom of my heart, I thank you.

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CHAPTER # 1

Problem Definition Summary

This section will provide further understanding of the problem, this thesis seeks to solve. The following is a depiction of compiled research into problems faced in the nursing industry. The problem definition will be broken down through problem finding/framing, an investigative approach, and furthering context and background knowledge.

« 1.1 Problem Definition »



Figure 1 – Nurse Experiencing Stress

Today's nurses are overworked and underpaid. Many of them struggle with large patient loads and high stress situations. Nurses suffer from a multitude of detrimental health effects due to their job descriptions. Many suffer from lack of sleep, depression, anxiety and many other mental and physical illnesses. While the current health

care system has served patients well, the well-being of the nurses providing such care has slipped through the cracks and have left these health care workers neglected. The solution which is sought, is one that enhances the lifestyle and quality of life of these nurses whilst in the work environment, through product design. This thesis project looks to better the well-being of nurses working in the high stress care system.

1.2 « Investigative Approach »

In an effort to comprehend the negative health effects of the nursing profession, a variety of research and analytical methods will be used. The methods that are used to further the understanding of the user are the following;

- Literature Reviews (peer reviewed articles)
- Product Bench Marking and Market Research
- User Observations
- User Interviews and Questionnaires
- Human Interaction Study (ergonomics)
- Activity Mapping

By using the research methods previously mentioned, a deeper appreciation for the struggle's nurses face on a daily basis in the work environment, has been developed. As a result, the following questions have been able to answered;

- Could this solution be implemented with little to no backlash from the community?
- What types of materials should be used and avoided?
- What types of health detriments could this solution solve?
- What features should the solution incorporate in the design?
- Are there any current solutions on the market?
- How can lifestyle and quality of life be addressed?

1.3 « Background, History and Social Context »

The nursing profession has existed throughout history and has evolved over time to what it is today. Nursing is defined as the providing of medical care and attention to those in need. Not only do they provide such care, but they are also responsible for the promotion of health and prevention of illness within their communities (ICN, 2020). With efforts from Florence Nightingale, modern nursing was reinvented leading to safer and more sterile practice. Without nurses' previous great plagues and other global illnesses would have had tremendously worse effects on the population of the world.

Despite the fact that the nursing profession is and has been essential to the progression and success of the human race, these health care workers are often neglected. However, nurses still continue to expose themselves to harsh working conditions in order to take care of those in need. Exposure to viruses/bacteria, long hours that are subject to mandating, high stress, emotional distress, physical demand/strain, are just some of the ailments nurses face as a result of their occupation. Comprehension of such detriments is obvious and not difficult to see.

Nurses have equipment that they use on a daily basis to help them with certain tasks.

Unfortunately, even with the latest equipment, the mental and physical health of the nurses is ignored. They are looked at like machines, employed to do a job and do just that. However human beings are

more complicated, and are subject to certain trauma



Figure 2 - Nurse Interacting with Equipment

which cannot be solved by simply switching out damaged parts. These nurses lack proper regulation, services and equipment in terms of their overall health and must be addressed, as studies have shown need for them will only become evermore increasing. Not only is the health of nurses a concern but

some articles say that nursing has become one of the most dangerous jobs as abuse and understaffing continue to rise (Landis, 2017). This comes as a surprise as nursing is often seen as a noble and harmless profession.

This thesis seeks to improve the overall health and well-being of nurses through providing a wearable solution that can help mitigate the tension and ailments which come as a result of the occupation, while also not impeding with the interaction of nurse and patient. Applying a solution to this demographic can result in further expansion and development into many other industries subject to similar working conditions, such as factory work, construction, etc.

CHAPTER # 2 – Research

« 2.1 User Research »

This chapter will consist of research which was conducted throughout the duration of the design process. The chapter contains information pertaining to both the user and the product. Research gathered will help to gain a deeper understanding of the target demographic and how the products that are available today, are sub-par.

2.1.1 – User Profile

Primary User

Nurses

The primary user of this product would be Health Care Workers, more specifically nurses. This demographic is exposed to a multitude of health detriments due as a result of their job descriptions. They are subject to long shifts, many hours on their feet, mandating and shorten breaks, contributing to the need for a product as such.

Secondary

Healthcare Worker Management & Administration

The secondary user of this product are higher ups in the nursing industry, in administration positions. This would include both nurse educators and nurse managers, as they have first exposure to any new products coming into the hospitals, in which their employees would be exposed to.

Tertiary

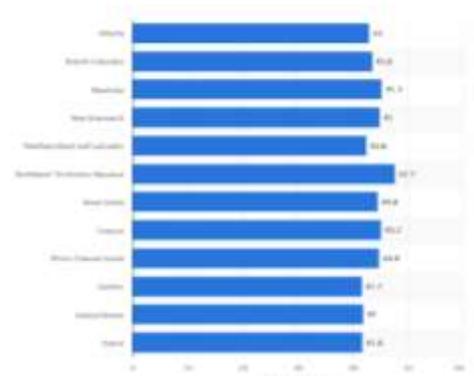
Patients & Researchers

Patients would be a tertiary user of this product. Although they would not be in direct contact of the product, they would be one of the first to reap its benefits as their nurses would be more alert, resulting in more thorough care. Researchers would also be considered a tertiary user as personal use of the product would not be necessary. However, exposure through observations of its benefits is how a researcher would interact with this product.

Demographic

Age & Gender

According to the Allied Staffing Network, the average age of nurses is on the rise as the majority of the workforce resides in the 50 and over age range. A study shows that the average age of those becoming Registered Nurses is 30 and that 75% of the nurses will be retiring by 2050, leaving extremely big shoes to fill within the healthcare system. **Figure 4**

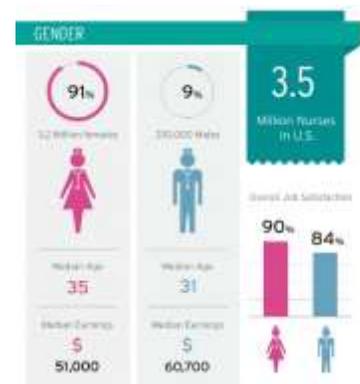


demonstrates this trend within Canadian provinces.

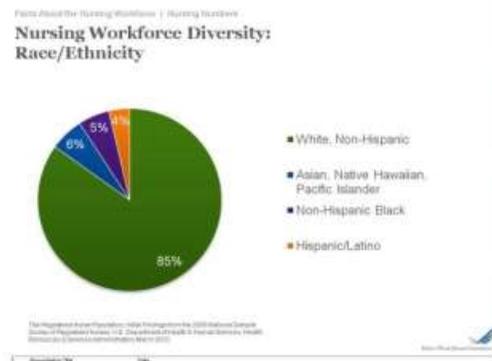
Gender

The nursing industry predominantly consists of women. Men are largely outnumbered as a 2015 census has shown that they make up 8% of the nurse population which has only increased by a mere 1.1% since then. **Figure 5 depicts the**

dominating gender amongst nurses within the U.S.



Race and Ethnicity Upon further investigation of the nursing demographic, minorities make up a small portion of the workforce, with the Caucasian ethnicity dominating the segment. Accordingly, the Caucasian nurses make up 80.8% of nurses and the remaining 19.2% are of visible minority cultures. Interestingly enough this trend seems to vary depending upon location, having some areas oppose these statistics. **Figure 6 visualizes this data within America.**



Income & Earnings When looking at income Nurses like other occupations, experience leads to greater wage earnings. However, wages are also affected according to location, with Manitoba and Alberta making noticeably more than other provinces. Unfortunately, statistics related to the percentage of those making a specific income is unavailable. This information would pose useful as it would help understand how many nurses are earning a decent income, as salaries range from 32\$/hr to 42\$/hr. **Figure 7 shows average earnings according to location within Canada.**

Average (Median) Hourly Wages for Registered Nurses in Canada

Location	2016 (CAD)	2017 (CAD)	2018 (CAD)	Year
Calgary - Alberta*	42.81	43.81	44.38	2017
Edmonton - Alberta*	42.61	43.81	44.68	2017
Vancouver / Lower Mainland Southwest - British Columbia	32.85	36.71	43.89	2016
Winnipeg - Manitoba	33.25	36.06	42.00	2016
Fredericton / Oshrota - New Brunswick	37.00	38.00	42.31	2016
Halifax - Nova Scotia	39.38	38.50	42.80	2016
Toronto - Ontario**	32.00	35.00	41.00	2016
Ottawa - Ontario	32.00	35.00	42.42	2016
Windsor / Sarnia - Ontario	35.15	35.00	41.00	2016
Hamilton / Niagara Peninsula - Ontario	32.00	35.00	41.00	2016
Prince Edward Island	32.15	35.43	42.25	2016
Montreal - Quebec	31.36	31.80	39.48	2016
Saskatoon / Regina - Saskatchewan	32.00	40.00	43.89	2016

Education The majority of nurses today are looking to attain higher education when starting their nursing careers. With 45.4% earning an Associate Degree in

nursing, 34.2% completing a BA and 20.4% achieving their education through in hospital diploma programs. **Figure 8 represents a more recent statistic in nursing education.**



Demographic Summary

<i>Demographic</i>	
<i>Age</i>	Early 20s - Late 50s
<i>Gender</i>	Predominantly Female (91%)
<i>Race & Ethnicity</i>	Caucasian (81%)
<i>Income & Earnings</i>	University Level Degree
<i>Education</i>	40\$-90\$ Thousand Annually

Table 1 - Basic Demographic Information

The table above, is a summary of all the demographic data collected, through analyzing healthcare workers. Typically, nurses are often caucasian women, in the early 20s to late 50s. They are often enter their way into the field through degree programs and earn on average anywhere from 40 000 to 90 000 dollars per year.

User Persona

Name: Jennifer Carter

Age: 32

Occupation: ICU Nurse

Income: \$68 000/year

Education: Bachelor in

Relationship Status: Married w/ 3 Kids

Location: Calgary, Alberta

Years of Experience: 5 Years

Social: Works with 14 other Nurses, however sticks to oneself outside of work

Activity Level: Constant walking at work,

Moderate activity outside of work

Hobbies: Baking, Hiking, Watching TV Game Shows



Image 1 - User Persona

Profile

Jennifer Carter is a Caucasian female working in the ICU unit. She has attended Ryerson University where she earned her Bachelors in Science of Nursing and later moved to Calgary, Alberta where she found a better opportunity for furthering her career. Jennifer has also earned a diploma in Marketing but chose to leave that life behind at the age of 23, to pursue a career in nursing. She has now accumulated 5 years of experience working at Calgary Metro Hospital, where she was hired directly after graduating. Taking care of the ill and rehabilitating them to their former health is what she enjoys most about her job.

User Behavior

Jennifer is often on her feet as she strives to provide care to her given patient load. Being in the ICU situations constantly change at a moments notice, requiring her to be adaptive and quick thinking. She rarely has time to take a break and often solely interacts with the doctor on call. External interaction with specialists and other nurses have led to friendships that are confined within the work environment. Although this work is tiring, Jennifer finds it rewards and she cares for the health of her community.

Jennifer and New Technology

Jennifer has been in contact with healthcare equipment ever since her days in practicum as a university student. Since then she has grown accustomed to the way things operate, however is willing to learn as she understands that the healthcare industry is ever changing. While she is welcome to change, she is troubled by how easily some new technology can be implemented into her daily routine of providing care to her patients. As the hospital pays for all incoming new tech, Jennifer does not have to pay for anything, including training of how to use this new equipment.

2.1.2 – Current User Practice

User Behaviour Summary

Activity Level According to a study conducted in regards to nurse health behaviour, found that 50% of Registered Nurses participate in the recommended daily amount of physical activity. This has led to 30% - 53% of the nursing population being overweight, similar to that of the American national average (Bevans 2017).

Common Health Detriments

A simple search has led to massive findings. Nurses have been forgotten about

in today's healthcare system as many suffer from a variety of health issues. The most common being cardiovascular disease and gastrointestinal disease caused by changing shift work. It is also important to note that the job description is extremely physically demanding, and has led many to physical fatigue and overall exhaustion.

Mental Health

The detriments to the wellbeing of nurses caused by this line of work goes beyond just the physical, as it also affects the mental. Due to sleep deprivation and other external factors as a result of the job description, many suffer from anxiety and depression. In fact, 36.4% of nurses have tested positive for Depression as well as 26.1% are positive for anxiety (Canadian Federation of Nurse Unions 2020). Unfortunately, the troubling statistics do not stop there, as 1 in 3 nurses have admitted to contemplating suicide (Canadian Federation of Nurse Unions 2020).

Lifestyle

While nurses can be seen as healthy, some of their behaviours can state otherwise. With weekly shift changes, and long hour stretches, getting proper sleep is seemingly impossible, leading to sleep deprivation. Studies have also proven that 62% of nurses choose to eat out (junk food) a minimum of 2 times a week (Bevans 2017). Sleep and eating are not the only areas of life nursing adversely effects. The social lives of these practitioners also suffer as many of them are unable to maintain a proper work-life balance, missing gathering and holidays due to rotating schedules (Eastern Illinois University 2019).

Purchasing Power Nurses are required to bring any equipment they need apart from the supplies that are necessary for providing care to the patient. Items for strain prevention, comfort and well being are often purchased at the discretion of the nurse. As shifts are often 8-12 hours long, comfort is a major purchasing purpose. Items like compression and footwear (insoles) are helpful however rely on the nurse to acquire such. Creating a system that provides nurses with a proper incentive for self-care is required for positive change.

Location Nurses are an essential part of today's healthcare system. They are needed in many different areas within the industry. According to an article written by Rasmussen, nurses are able to work outside of the typical hospital environment. Registered nurses can be found working in clinics, schools, housing facilities, public health facilities and more (Malvik, 2020). In a 2019 study conducted by the Canadian Institute for Health Information, data has shown that over 45% of nurses currently work outside of the stereotypical hospital setting (Canadian Nurses Association, 2020).

2.1.3 – Activity Mapping

User Observation Preliminary Info

As the nature of nursing is strenuous and they are tasked with multiple different duties, it is important to take a wholistic approach to tacking their activity. With most of the equipment nurses are exposed to benefitting the patient, it leaves the healthcare worker utilizing such, out of the equation. To simplify this approach, an observation of one of the most strenuous tasks in the nursing job description must be analyzed. Therefore, for the purpose of this thesis the following process will focus improving and

evolving therapeutic remedies commonly used by nurses in order to help elevate both bodily tension and stress, in an effort to promote overall well-being.

Nurses unfortunately do not have many options when it comes to self diagnosed therapy while working on the unit. Compression socks are the most commonly used prophylactic measure worn by nurses in an attempt to help deviate negative health detriments. This thesis looks to evolve the compression sock to help further mitigate bodily



Image 2 - Compression Sock

strain as well as improve mental fortitude. Figure # is an example of compression socks available in the market today.

The proceeding will be a demonstration of how nurses interact with their compression socks on a day to day basis. These interactions will include the following;

- Application and Removal
- Daily Wear
- Performing Duties

Due to the current COVID-19 pandemic access to hospitals for an in-person observation is highly limited. Therefore, a YouTube search will be use in order to acquire demonstrational videos and information in regards to such.

User Observation

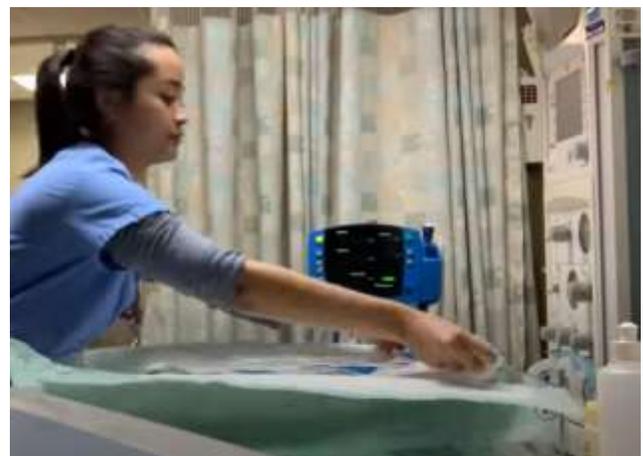
Application and Removal



Daily Wear



Performing Nursing Duties



D <input type="checkbox"/> Distraction <input type="checkbox"/> Distraction <input type="checkbox"/> Distraction	U <input type="checkbox"/> Unstable <input type="checkbox"/> Unstable <input type="checkbox"/> Unstable	W <input type="checkbox"/> Wound <input type="checkbox"/> Wound <input type="checkbox"/> Wound	W <input type="checkbox"/> Wound <input type="checkbox"/> Wound <input type="checkbox"/> Wound
S <input type="checkbox"/> Skin <input type="checkbox"/> Skin <input type="checkbox"/> Skin	A <input type="checkbox"/> Assessment <input type="checkbox"/> Assessment <input type="checkbox"/> Assessment	B <input type="checkbox"/> Bleeding <input type="checkbox"/> Bleeding <input type="checkbox"/> Bleeding	R <input type="checkbox"/> Respiratory <input type="checkbox"/> Respiratory <input type="checkbox"/> Respiratory

Conclusions from Observations

After conducting these user observations, many considerations have come to fruition. Nursing is an extremely tasking profession as it requires workers to be on their feet all day, while also exerting physical efforts, such as lifting, pulling and twisting. These actions are all performed with minimal support, and often lead to injury. Access to a product that combines tension relief as well as promote mental stability must be applied in order to benefit the overall well-being of healthcare workers. The following is a list of key considerations that must be taken into account:

- Prevention therapy must be applied to other high wear and tear areas of the body
- Compression material would be beneficial
- Must not impede with daily nursing tasks
- Comfort is of high priority as workers often work 8-12hr shifts

2.1.4 – Ergonomic Research (Existing Products)

Compression socks are offered in multiple different sizes as well as compression ratings to fit the specific needs of the consumer. While many are available to the general public to purchase, some do require a physician prescription in order to acquire such ratings of compression. Proper fit and function



are capable through the apparatus's elastic nature. The follow is an image of how a compression sock works, as it serves its purpose however, lacks a wholistic approach that encompasses the entire body.

This sock as well as many others on the market are limited in terms of the relief, they can offer the user. Design across the board is also fairly standard as they lack additive features, resulting in user needs. Limitations of relief stem from the form factor of this item. As mentioned in the previous chapter, nurses are exposed to several adverse health effects, which deteriorate the mind and body of these health care workers.

When designing for nurses there are many ergonomic considerations that need to be taken into account in order to thoroughly satisfy their needs. This thesis will focus on better serving the nursing population, creating a solution that will enhance the lifestyle through mitigation of high stress.

2.1.5 – Safety and Health Research

Health and safety are common topics of discussion within the healthcare industry, however more often than not, HWC are put in harms way. Nurses face many health and safety risks as apart of their job description, with sleep deprivation and stress being the leading liabilities. A 2019 article revealed that 49% of nurses suffer from sleep deprivation due to an insufficient amount of quality sleep (Christian, 2019). Another 2017 study discovered that 86.7% of nurses have experienced some form of moderate job-related stress and an impressive 70% have experienced medium to high stress (Keykaleh MS, et al., 2017).

Currently there are no products on the market that are specifically tailored to meet the needs of these nurses. Most equipment nurses have access to, help to provide better care to the patient while mitigating some sort of singular strain. For example, lifts are designed to help the healthcare worker transport or move patients with mobility issues while relieving possible muscular and skeletal strain previously associated with the task. Unfortunately, not all the duties these nurses face on a daily basis

have tools like this and currently there are no products to help relieve the two most common detriments of these nurses. This research will help to inform the design in order to address the such concerns.

2.2 – Product Research

« 2.2 – Benchmarking »

2.2.1 – Product Benchmarking – Features and Benefits

When looking at different products on the market that relieve strain and stress, the amount of results was truly endless. There are many solutions that are used to solve different types of strain, with each product focusing on a singular problem area. However, there is a lack of a wholistic approach available to the consumer today. For the purpose of this benchmarking exercise, pain relieve equipment was used as the focus for further examination.

4 products were evaluated and the following graph demonstrates these pain mitigation products based on the following criteria;

1. Specific or wholistic
2. Relief or preventative

INSERT GRAPH

After completing this graph comparison, a new design opportunity exists in the **preventative and wholistic** sections.

Features and Benefits

An analysis of the promotional material surrounding these products was conducted in order to retrieve information in regards to the features and benefits incorporated in such and were commonly found.

The adhering graph illustrates the findings of this research;

Key Benefits and Features of Comparable Products	
<i>Benefits</i>	<i>Features</i>
Comfort	Material
Style	Adjustability
Support	Relief
Relief	

Table 2 – Top features and benefits commonly found in pain and stress mitigation products

This graph demonstrates key information that must be taken into consideration during the design process. It is key that the product developed throughout this thesis project must be **comfortable**, **adjustable** and **provide some sort of relief** to the consumer, in order to be successful.

2.2.2 – Benchmarking – Functionality

The functionality of the previously mentioned products have varying degrees of user input associated with each in order to be effective. They all are possible solutions for some of the adverse health effects experienced by healthcare workers and all do so in different ways. The list below highlights the functionality of these products;

- The relief offered by each product directly relies on how the user applies each solution
- Solutions that are additive often need replacing, whereas standalone products are more durable and longer lasting.
- Braces are the only option for preventative solutions and are the only highly adjustable option
- There are major design opportunities for a nurse specific pain and stress mitigation system that is both preventative and wholistic

2.2.3 – Benchmarking – Aesthetic and Semantic Profile

Due to the fact that there are no current solutions specifically design for nurses an aesthetic analysis of their equipment cannot be conducted. In order to get some form of information, research into pain relief products were used. In this regard, aesthetics are not typically as important as the function of the given product. With relief being the main focus, additive features such as adjustability and useability are incorporated to ease the burden of wearing/using such solutions.

The shape and form of these products are often altered or completely designed around the human anatomy, and physiology. Due to the fact that most if not all of these products are wearable, and are designed to be worn for extended periods of time, the form is influenced by the contours of the human body and the type of alleviation that is being offered. After these considerations have been taken to account, do companies then add their brand language in order to differentiate themselves from the competition.



Figure 3 – Shock Doctors use their Logo in their products

2.2.4 – Benchmarking - Materials and Manufacturing

Most compression and supportive apparatuses are constructed using similar materials that are purposefully chosen for their durability, comfort and breathability. The following is a list of commonly used materials;

- Lightweight polyester/lycra & Neoprene for moisture wicking
- Engineered Copper Nylon/Spandex
- Padding (EVA Foam)
- Aluminum structural supports

Supportive braces range in price, as higher quality models have more exotic materials and provide a wider range of support. With these solutions being wearable, it is important to incorporate comfortable materials wherever possible, in order to appeal to the user.

Manufacturing

Being that manufacturers of these products are wide spread and the current COVID-19 pandemic has limited interaction an online observation of the Legend manufacturing process was conducted in order to gain further understanding. These compression apparatuses are mainly constructed using an automated knitting process and are sent down an assembly-line system, where further dying, boarding and packaging are completed. Rigorous testing is also conducted, in an effort to provide customers with the best possible product, ensuring quality control.

For the purpose of this thesis the use of current available materials will be used in order to be competitive in the market while keeping the price point appealing to the potential user. However, due

to additive features that will be incorporated in the design, new materials will be weighed but will only be used if deemed necessary to provide a viable benefit to the consumer.

2.2.5 – Benchmarking – Sustainability

While observing the Legend manufacturing process it was discovered that they are located in North Carolina, USA in an effort to influence quality control and product development. As far as sustainability is concerned their location is closer to their target market, reducing their overall carbon footprint as distribution is minimal. The equipment that is being used to construct these products also positively impacts the environment, as the knitting process cuts disregarded material that is common in the textile industry, to a minimum.

Unfortunately, it there are some major negative environmental impacts through the materials being used in these products are often synthetic, which result in the burning of fossil fuels in order to produce such. With the lack of environmental impact consideration in the materials aspect of the current design development, this thesis will further explore possible materials in order to create a solution that is more eco-friendly and possibly bio-degradable if possible.

Conclusion

The research conducted to gather information on existing products that the target market would be interested in, or are currently using, has revealed some insightful findings. This research has displayed different ways in which the user interacts with such products and how there are areas that can be improved. As a result of this research there are clearly many opportunities to further design an application that can better serve the healthcare workers of today.

Chapter #3 – Needs Analysis

This chapter will look to create an improved solution that will address user needs that are currently lacking in the products that are available today. These needs will be observed through user interviews, activity mapping and schematic/ergonomic analysis [user research & human factors (Henry Dryfus)]. There will also be an exploration into how manufacturing and sustainability in order to produce a design solution that is thoroughly considered.

« 3.1 – Needs Analysis »

3.1.1 – Needs/Benefits Not Fulfilled from by Current Products

Current stress and strain mitigation products are stand alone solutions that do not work in tandem with one another. They are often uncomfortable, and unsightly, causing them to be a nuisance to wear or apply. Convenience is also an issue as some applications are more difficult than others and require some replenishment. Although seen as cumbersome, these solutions are beneficial to the wearer, however there is room for improvement. The following is a table of possible opportunities to for design.

Needs	Benefits
Comfort	<ul style="list-style-type: none"> • Breathable/Moisture wicking Material • Ease of Movement
Productivity/Performance	<ul style="list-style-type: none"> • Reusable without need of replacement • Provide Long Lasting Relief • Provide Preventative Relief instead of band-aid Solution • Antimicrobial to Reduce need for Constant Washing

Aesthetic	<ul style="list-style-type: none"> • Allow to be Hidden underneath Layers • Thin and complimentary of Body Shape • Friendly/Inviting color blocking Representative of Job being done
------------------	---

Table 3.1 – Areas of Improvement for Current Products

3.1.2 – Latent Needs

Latent needs were also examined, following guidance from Maslow’s Hierarchy of Needs in order to identify what motivates the need for enhancement.

Benefit	Fundamental Need(s)
Comfort	Physiological Need (Bodily Interaction), Safety (Supplementary to Physiological Need)
Productivity/Performance	Safety (Step Towards Psychological Needs)
Aesthetic	Esteem (Inspire Confidence, while being Unobtrusive)

Table 3.2 – Benefits in guidelines of Maslow’s Hierarchy of Needs

Rationale of Needs

Comfort

Healthcare workers remain in their garments for upwards of 12hours in a single day. It is key to prioritize comfort in order to allow the wearer to be relaxed as possible and perform daily tasks as best and efficiently as possible. Due to the fact that the user’s environment is often chaotic, the ability to focus on a given task is of high importance.

Productivity/Performance

Improving preventative measures can reassure nurses that health and safety whilst on the job has not been neglected. An improvement to the duration of relief can also benefit job performance, as discomfort will no longer be an ailment. This new found sensation of relief could also reap positive psychological effects as the mind is freed from pain and stress.

Aesthetic

Although the appearance of pain relief apparatuses are typically determined by their function, style is important. Due to the fact that healthcare workers are exposed to the public, it is vital that the appearance of their visible clothing is soft, friendly and inviting, in an effort to be pleasantly received by their patients. This reduction in friction between caregiver and patient, can result in friendly interaction and improved self-esteem/confidence.

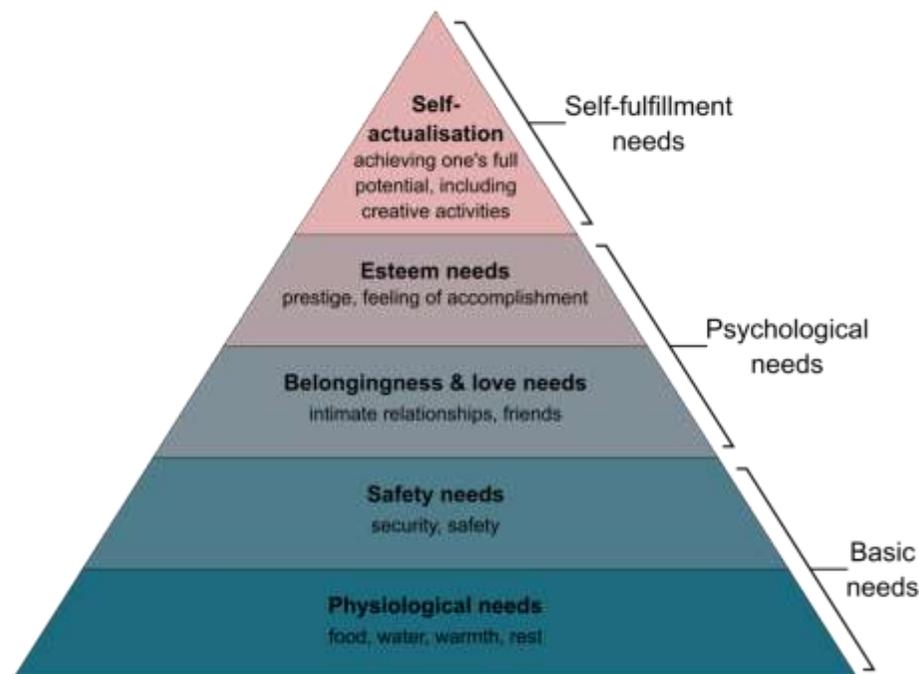


Figure 4 – Maslow's Hierarchy of Needs

3.1.3 - Categorization of Needs

This thesis will focus on the mitigation of strain and stress amongst nurses in the high stress healthcare environment. The majority of these needs were identified through the observation of the interaction of other relief products as there are no nurse specific solutions. These observations were also coupled with advisory interviews to find user specific pain points, providing enlightenment to the needs experienced by the wearer. The needs identified are categorized in the following list.

Wishes/Wants:

- Integrated intelligent materials (Heating, Cooling, Breathable, etc.)
- High Adjustability that is adaptive to changing body shapes
- Reduced fatigue during extended wear

Immediate Needs:

- Automated Relief (Requiring lack of user input)
- Cognitive Feedback (Analytical Data of Mental Health)
- Full Body Relief
- Wholistic Approach to Therapy (Relief and Prevention)

Latent Needs:

- Stylizing
- Convenient to use
- Ease of Maintenance (Reduce need to be Laundered)

3.1.4 - Needs Analysis

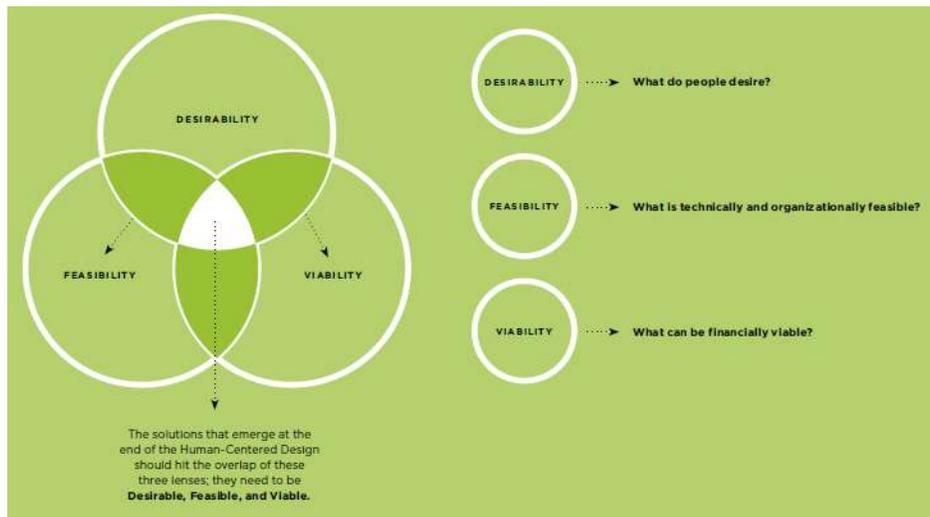


Image 3 – IDEO Approach to Human Centered Design

Desirability Nurses are in their garments for long periods of time. These garments do little to nothing in terms of providing a form of alleviation. Creating a solution that would relieve healthcare workers of job-related detriments would be desirable. This solution should also include a cognitive aspect in order to prevent fatigued nurses from being mandated and overworked.

Feasibility Due to the fact that this new iteration of intelligent garment will be utilizing existing technology, it is believable that the feasibility of this garment is within reach. The only concern would be accessibility due to cost, as this solution does have the potential to be high priced, however can be solved through subsidization offered by the government and organizations.

« 3.2 – Useability Analysis »

3.2.1 – Activity/Workflow Mapping

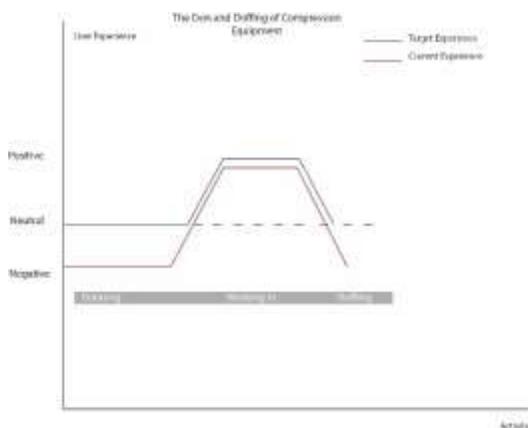
In order to gather information related to this topic, as there are no similar current solutions. An evaluation of a relevant product had been made. Below is a step-by-step breakdown in the don and

doffing of a compression sock. This was used to inform the feelings felt during this experiment which later would help make decisions in how the final design could be applied to the body.



Image 4 – An image of the step-by-step process of the application of a compression sock.

3.2.2 – Activity/Experience Mapping



This graph demonstrates the experiences felt by the user during the don and doffing of compression wear process. Evaluating such allowed for development in creating a solution that was easier to apply, positively increasing the overall user experience.

« 3.3 – Human Factors »**Introduction**

The nurses of today are overworked and exhausted in more ways than one. According to a study conducted amongst the population of nurses in the US, 70% of nurses have experienced moderate to high stress related to work (Ghomian, Etc., 2018). Another journal states that the health care industry sports a surprising number of occupational hazards including physical, verbal and emotional abuse (Alhassan, 2018). Nurses are a valuable part of today's aging society, and should be cared for in such a way that protects and prevents them from detrimental health effects. A thorough review process was created in order to gather information on various measurements and interactions such an apparatus would need to consider in order to be effective. Results have revealed that measurements are delicate and need further development. The key takeaways based on this research are structural rigidity will be a highlight moving forward.

Literature Review:

With the identification of the target audience, the 5th to 50th percentile has been studied specifically as this is where the demographic fits in terms of an anthropometric stand point. The Measurement of Man by Henry Dreyfus has been used to evaluate the measurement and provide information in relation to human proportion. References to the overall health of the nursing population have be used in order to consider common injuries and occupational hazards. Furthermore, using a variety of sources has led to a complete understanding of how to better care for the healthcare community.

Methodology:

The ergonomic evaluation of current self-therapeutic and supportive designs has a fair degree of variation in how a solution is achieved. Therefore 3 categories of current solutions will be analyzed to further the understand of human interaction.

	Category of Solution	Purpose
1	Compression	To Help with pain mitigation as well as promote blood circulation.
2	Support	Improve mobility and prevent possible injury
3	Therapy	Stabilize equilibrium to promote overall health and well-being.

Objectives:

The purpose of this exercise is to discover the ergonomic challenges faced current day solutions in terms of a full-bodied interaction standpoint. With full-bodied interaction being a major criterion of this thesis project, a solution encompassing the entire body from head to toe will be the goal of this desired solution. This evaluation will outline the results of an analysis of the, don and doffing of such an apparatus as well as the ergonomics and user interface being collaborated with.

Decision(s) to be Made:

The high stress health care system is dominated by the female population, with 92% of all nurses being female and 8% being male (Michas 2019). Due to the focus on proper ergonomic design,

anthropological measurements and percentiles are key to creating a widely accepted solution. For the purpose of this project the Female 5th-50th percentile will be analyzed to provide insight to the consideration that need to be made.

Three Body Part Interactions:

- 1) Limb Strap (Arm & Leg)
- 2) Compression Sock (Feet)
- 3) Compression Vest (Chest/Vitals)

Description of Target User:

The target demographic, although narrowed to a female focus, there is still a broad range in terms of age and measurements. This demographic ranges from 22-65 years of age, which is a spectrum no longer subject to growing or shrinking, therefore solidifying the measurements to be considered. A proactive nurse that has used personal therapeutic solutions (ie. Compression socks, shoe insoles, etc.), looking to further care for oneself, is the ideal candidate for this apparatus.

Evaluation Process:

Due to the large scope of this project, and taking into account all the human interaction components, this evaluation will utilize both a 1:1 scale CAD model and a physical 1:1 scale Mockup. The evaluation was done creating a custom anthropological model taking measurements from both the 2.5th percentile female and 50th percentile female, averaging the findings to create a design that could fit both end of the spectrum as well as anyone else in between. The purpose of the evaluation was to analyze the following;

- 1) Limb Strap: Sizing, Don & Doff. To ensure the user is able to make full use of the compression made available by this apparatus. This will also help to further the understanding of the ease of use.
- 2) Compression Sock: Don & Doff, Variation. To ensure the apparatus is as convenient as possible, as well deciding on the location of the adjustable straps and their effectiveness.
- 3) Compression Vest: Sizing, Don & Doff. To ensure the range of percentiles can make use of the vest and compression is applicable throughout the spectrum (elasticity).

Description of User Observation Environment Use in this Study:

As the current COVID-19 pandemic has continued to progress and worsen, a physical walkthrough was unable to take place. However, a verbal explanation of the environment was provided via sponsor (Charlene Alcaraz, NICU Nurse), to provide the knowledge needed to complete this process.

Location: Milton, Ontario & Mississauga, Ontario

Timeframe: 01/21/2021

Results:

The following is a depiction of the custom anthropological model, wearing the entire apparatus. This was achieved through the Clo3D program, and the results have furthered the understanding of measurements immensely.



Continuing on, the following are custom patterns created in Clo3D applied to a 1:1 scale model. The patterns were draw onto the fabric then cut to size and fastened together using hot glue. The following are visuals of the don & doffing of each device.

Sock Compression:



Calf Strap:



Shoulder Strap:



Analysis:

Limb Compression

Process: The user applies the compression to the desired location, adjusting the tension using the adjustable strap. The Don & Doff process will typically be done single handedly, with no additional help.

Ergonomic Evaluation: The measurements of the limb compression straps range due to the limb size as a certain amount of surface area (muscle) must be covered in order to be effective. Due to the organic shape of the patterns, the basic measurements will be provided. The bicep strap, is 19.76cm in length and 13.49cm in width, the strap portion of the device is 15.24cm in length and 5cm in width. The dimension of the bicep strap must be adjusted as the strap does not fully encompass the bicep (please refer to pictures above). As the measurements of both the 5th and 50th percentile were averaged in this ergonomic study, a margin of error must be considered. The calf strap was more successful as the dimensions were able to completely enclose the desired area. The dimensions were the following; 28.09cm at its longest point and 18.25cm in width, the strap portion followed the same dimensions as the bicep strap above. It is important to consider the movement of the nurses while using such a device, therefore the materials chosen will allow for the flexion of muscles, resulting in a more comfortable and effective experience. Furthermore, the materials to be chosen will include some sort of nylon, as nylon has an elastic modulus of 2.7 GPa (SpecialChem, 2021).

Compression Vest

Process: The user will step into the vest and secure it using the straps found on the shoulder. The user will use the integrated technology to trigger the adaptive compression based on the interaction of sensor across the body.

Ergonomic Evaluation: The key considerations within the compression vest, will be where the compression air pockets fall on the body, and how the user interacts with such. The vest was also created using the same custom anthropological model, the measurements are more critical in this area of design, as the vest is a 1 size fits all, with a limitation on the customizability, due to maintaining effective relief. Despite these limitations the following measurements have been assessed. The air pockets along the bust of the user will fall 4.11cm below the chin at its highest point and 22.94cm at its lowest point, with a total width spanning 25.65cm across the bust of the user. This will result in a bust air pocket that is able to cover both ends of the spectrum. The same was done for the spinal air pocket, and the following are the results: 11.25cm below the orbital bone at its highest point and 32.05cm at its lowest point, with a total width spanning 24.80cm across the back of the user. This spinal air pocket is designed to cover the important muscles on the back of the user at, the use of the back is vital to this occupation.

The air pockets will be completely inclusive throughout the entire range of users, as the desire of this project is to mitigate and support common pain points of all users. The pockets were designed to completely cover the common high traffic areas utilized in this occupation.

Compression Sock

Process: The user will utilize the three adjustable straps in order to customize the desired compression of the user.

Ergonomic Evaluation: Areas to take note of in this evaluation are, where the straps fall on the user during use, and how effective these straps are on. As the pictures previously displayed in this report show, the straps fall in the most effective areas of the foot. The following are the areas of the foot that seek to be covered by these straps, based on research; Extensor (Digitorum and Hallucis), Interior Extensor and Superior Extensor (Teachanatomy, 2021). The following are the measurements used; Sock size 9-11 (shoe size: 5-10US), Extensor and the Superior Extensor straps are 25.4cm in length and 7.6cm in width, with a separation of 15cm in between the straps, the Interior Extensor strap will be 6cm 25.4 cm in length and 6cm in width. These measurements will allow for optimal adjustability for user, while providing the proper amount of compression.

Limitations & Conclusion:

The following are the observations found and are noteworthy to mention;

- 1) The measurements of the limb straps need to be adjusted to fully enclose the desired extremity.
- 2) The structure of the shoulder strap needs to be considered in order to allow for ease of don & doff.
- 3) Pattern of shoulder strap needs to be further explored to eliminate the confusion of apply the apparatus.

Some User needs still need to be examined in order to provide a complete knowledge of a wholistic solution. The examination of current self-therapeutic products will help in the development of this product.

Alternative Solutions:

A major alternative solution is to use some structural aspects across the board in order to help provide added support as well as structure for the ease of application. A material to consider is abs and nylon.

« 3.4 – Aesthetic and Semantic Profile »**Symbolism/Aesthetics**

Currently, function has been prioritized over form as, relief solutions look to perform a certain task and do so as easily as possible. The overall aesthetics of such devices are dull and lack luster, as many are reminiscent of undergarment wear, and are covered-up by external outer layers. While this thesis looks to build upon similar solutions, stylizing will be of importance in order to create a garment that is desirable to wear for the user. Due to the lack of existing products that perform the desired functionality, pulling inspiration for an aesthetic profile has proven to be difficult. Nonetheless, design inspiration was drawn from products that incorporated similar technologies. The following is a table of images with products currently available in the market and how they might be useful in informing the design of this thesis concept.

Images	Informative Inspiration
	<ul style="list-style-type: none"> • Cushion • Targeted Relief
	<ul style="list-style-type: none"> • Compression • Patterning • Styling
	<ul style="list-style-type: none"> • Elasticity • Materials • Pain/Strain Relief
	<ul style="list-style-type: none"> • Thin Heating Element • Pain/Strain Relief
	<ul style="list-style-type: none"> • Air Compressor • Adaptive Air Compression • Readable Feedback

Table 4 – Informative Inspiration from Existing Products

Using existing products to inform the design will help to create a feasible product that is not only aesthetically appealing but also properly functioning. These products and others similar, will be further examined during the constructing of a full-sized model.

Semantics & Technological Possibilities

Relief wear should encapsulate some form of visual representation of alleviation. This can be achieved through the incorporation of technology and intelligent materials. An example of a beneficial material to be included in the design, would be bronze mesh lining that would allow for sEMG sensors to be used in the collecting of fatigue data. This can also be coupled with embedded air pockets that would adapt through the piggybacking of the signals from the sEMG sensors. Bluetooth technology could also be utilized in order to connect with an interface for both the wearer their supervisors, to inform of any predominate health concerns, that have the potential to hinder job performance. These few technologies could be extremely valuable to the overall well-being of healthcare workers.

Form

Following the natural contours of the human body will give heed to a comfortable unobtrusive design. The form should take on a sleek, thin, compression-like fit. This comprehensive form will allow for the user to be fulfill their daily tasks in a comfortable manner. While trying to portray a friendly and approachable figure, soft touch materials will be vital in the construction of this thesis project. All areas of the concept should be soft and squishable in an effort to increase the acceptance of care through a reduction in intimidating bulky materials. Colors must also be considered as there is a psychological effect associated with certain tones and hues. Blue and white will be major colors used in this design to follow existing trends within the healthcare industry.

Conclusion

The design solution should not only be inconspicuous for the user but also the audience that will have secondary or tertiary interactions with such, in order to maintain civility during patient interactions. Intuitive design is of high importance for don and doffing. Way-finding must also be considered to allow for the user to have full understanding of all controls and features integrated within the design.

« 3.5 – Sustainability – Safety, Health and Environment »

Sustainability not only deals with the environmental aspects of a design, however also includes health and safety as a consideration. With the globe in constant decay it is important to not only take into account the environmental impacts one has on the planet but also the health and safety of what is being created and how it might better the lives of the population that is seeking to be served.

Sustainable Initiatives

In order to appeal to a greater audience sustainability initiatives must be a part of this thesis's marketing plan. The first initiative that will be deployed is the desire to have this product be completely 100% biodegradable in order to reduce its impact on the planet and avoid the landfill as its final destination. Another sustainable initiative that is vital to the success of this thesis is, reducing the carbon footprint in the production/manufacturing process. This goal will be achieved through decreasing the amount of water and energy consumption, as well as switching factories to sustainable clean energy (wind, solar, hydro, etc.). Finally, fair trade is another vital consideration. The goal, to ensure that the all involved throughout the process from the farmers to the factory

workers, is paid a fair wage. This will not only benefit those who contributed to the final product through capital, but also help with mental and physical health.

Health

Implementing recycled materials (rPET) in the design has led to the concern of possible health implications. However research states that the incorporation of such, yields minimal concern as it takes constant exposure to heat (38 days at 150 degrees) in order to reach unsafe levels. Continuing on in health considerations related to material selection, bamboo is extremely safe to use and better serves the wearer through added benefits. The major benefit in relation to health, is the fact that the fabric is naturally antibacterial keeping the wearer in a more hygienic state.

Health is not only considered in material choice but also in the overall design and purpose of the product itself. According to the research stated in previous sections of this thesis paper, compression is key to serving the target audience. Compression not only helps with pain mitigation and support for the wearer, but also assists in increased blood circulation. Bettering the flow of blood throughout the body is essential to the alleviation of chronic illnesses related to the job (stress, migraine, high blood pressure, heart disease, etc.). This thesis product is better serving the nursing population due to the fact that their health has been the number one deliberation throughout the design process.

Furthermore, the implementation of health conscious initiative in the workplace needs to be investigated. A holistic approach to wellness will be mobilized in the workplace, to help those in need (Child Care Human Resource Sector, 2020, <http://www.ccscc-cssge.ca/hr-resource-centre/hr-toolkit/workplaces-work/workplace-wellness>).

Safety

Safety is another consideration that is of high importance.

Workplace plays a large role in the structure of today's society, therefore the safety of this thesis project has not only been examined through the design itself but also how safe the workplace is. In terms of the workplace, safety initiatives will be implemented and funded by the company itself, with an on board safety commission. Monthly inspections as well as initial training to all employees will be thorough and complete, in order to adhere to the Canadian Labour Code (Government of Canada, 2019 <https://www.canada.ca/en/employment-social-development/services/health-safety/workplace-safety.html>).

Continuing on in terms of safety of the design itself, the product will be as safe as wearing a brace or similar support. Due to the fact that an ergonomic study has been conducted, as well as the fact that the apparatus is 100% adjustable, the safety of this product is sound. If there is any concern, it would be the limitation of how much compression can/is being applied. Therefore each compression component of the design will not exceed 40mmHg in order to comply with the medical grade compression standards (Berkeley Wellness, 2016, <https://www.berkeleywellness.com/self-care/over-counter-products/article/rough-guide-compression-stockings>).

« 3.6 – Feasibility and Viability »

This product will use current manufacturing strategies in order to produce each I.C.A. suit. This will allow for ease of start up costs as well as a decrease in overhead resulting in a decreased cost. When looking at material, the results yielded a favorable outcome as the materials appeared cheap and readily available to the free market. All the materials chosen will be purposeful with style considerations following the design function. This helps to refrain from the use of expensive foreign materials in the design, help to keep cost down. With cost being of concern it remains secondary to the products function, in that if the function is more than adequate in turn driving up price, then so be it. This thesis product must be operational in order to drive the interest of the target demographic and increase desirability.

« 3.7 – Design Brief »

The purpose of this thesis is to better the well-being of nurses working in the high-stress healthcare environment. The following list will highlight ten key objectives in the development of a thoroughly beneficial concept;

1. Increase blood flow and circulation
2. Relief pain and tension in commonly damaged areas of body
3. Health promotion for those working throughout the healthcare system
4. Reduce the risk of harmful mandating
5. Ensure comfort for extended wear periods
6. Provide support for preventative therapy reducing risk of possible strain
7. Increase likelihood to wear through improved aesthetics

8. Create a solution that will adapt with changing shape of body (thin-overweight, barren-pregnant, young-old)
9. Incorporate beneficial technologies that would appeal to the user
10. Provide extra protection in the case of spilled bodily fluids or other potential biohazards

Conclusion

Through this research, the needs of the user and the requirements that need to be met by a product that would properly serve this population is quite extensive. Although complex in nature, a probable solution can be achieved through furthering the understanding of internals of existing similar products. The following section will focus on the development of a mitigating product, while keeping all previous research in mind.

Chapter #4 – Design Development

« 4.1. – Idea Generation »

4.1.1 – Aesthetic Approach

The initial aesthetic approach taken for this thesis was done by first finding form inspiration from products that are currently in the market. Finding market trends is vital to the aesthetic success of this thesis design as to assimilate into the wants & desires of the target market.

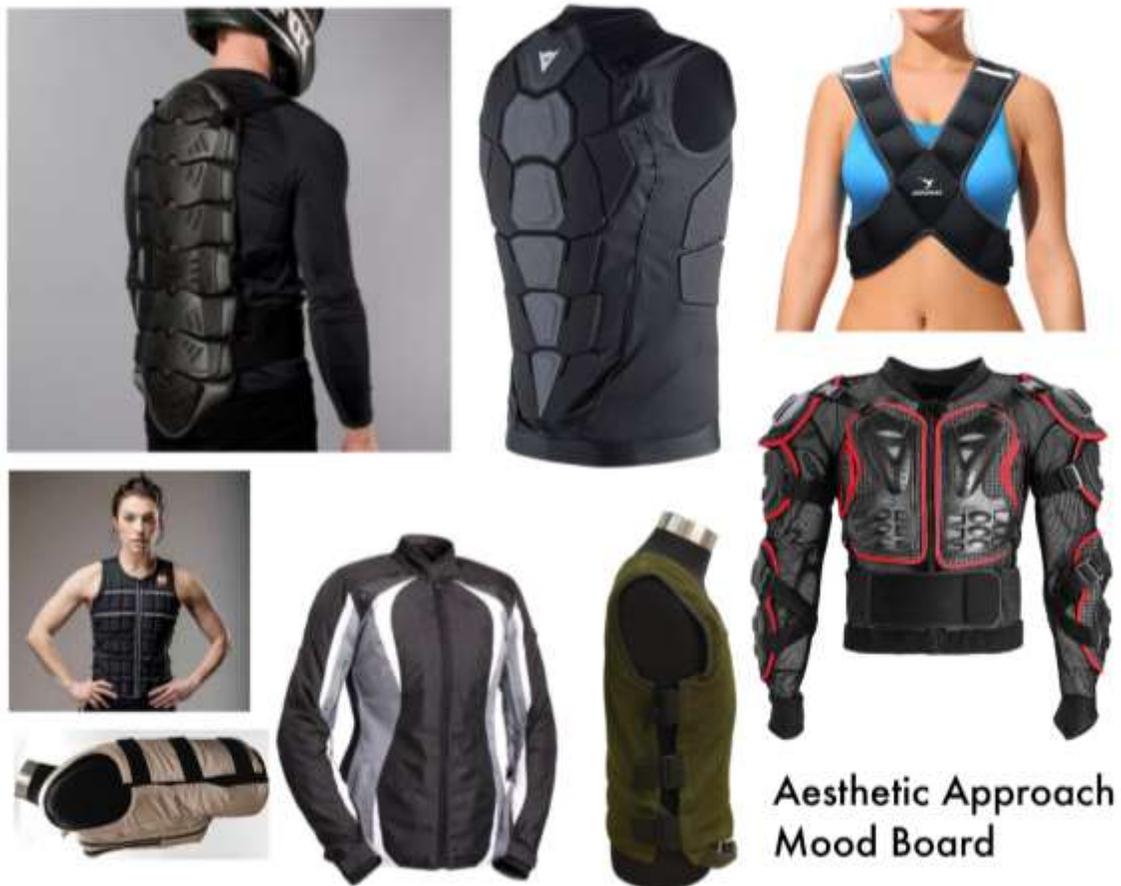


Image 5 – An image of the current products that were influential in the initial design process.

The form was heavily derived from motorcycle suits and other outerwear. It soon became evident that there was an opportunity to create a beneficial wearable suit for the target demographic, however the purpose of such an apparatus was still unclear. The semantics also began to take shape as the contour lines and multiple sections of these jackets offered a sort of aesthetic appeal.

4.1.2 – Mind Mapping

Utilizing a mind map was key to finding a viable solution to the problem at hand. Creating a visual that linked ideas helped to create a wholistic design approach. Through minding mapping an array of routes were able to be explored. It was at this stage a design brief began to take shape.

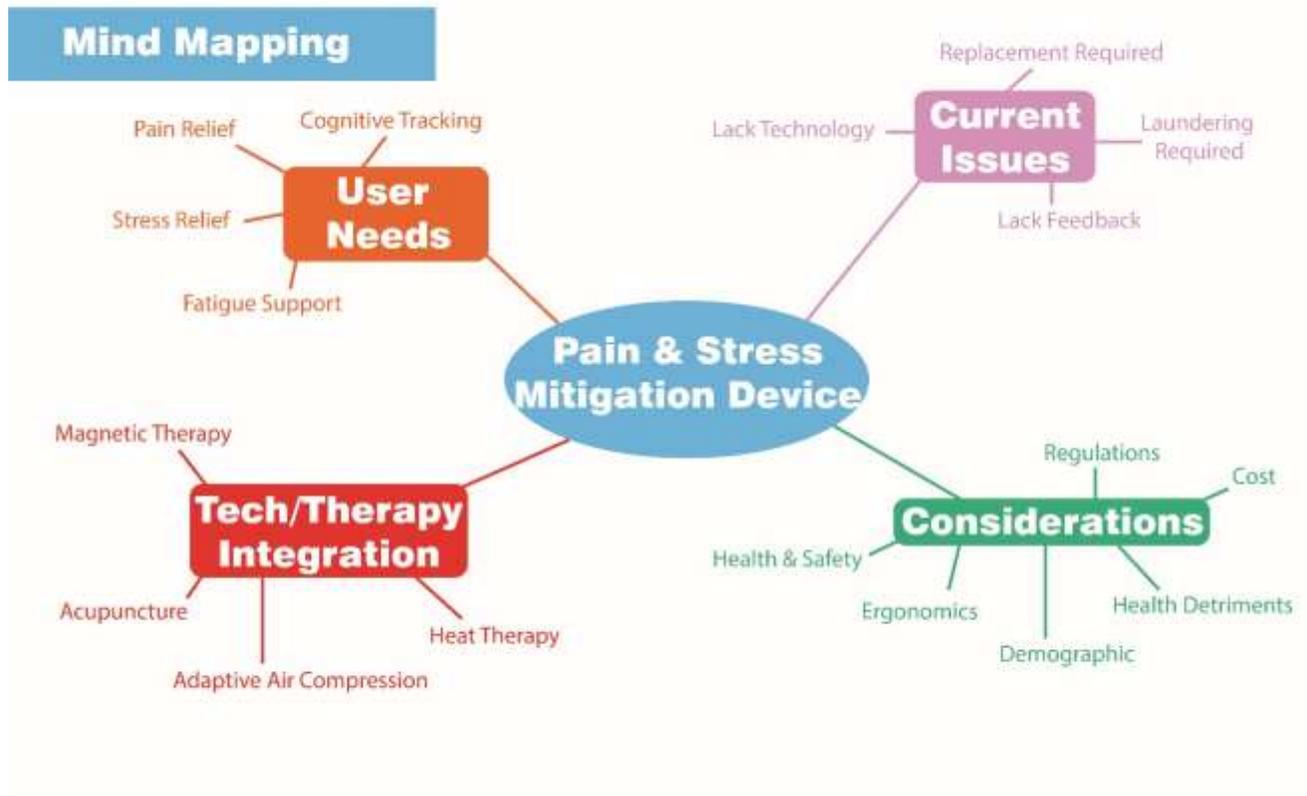
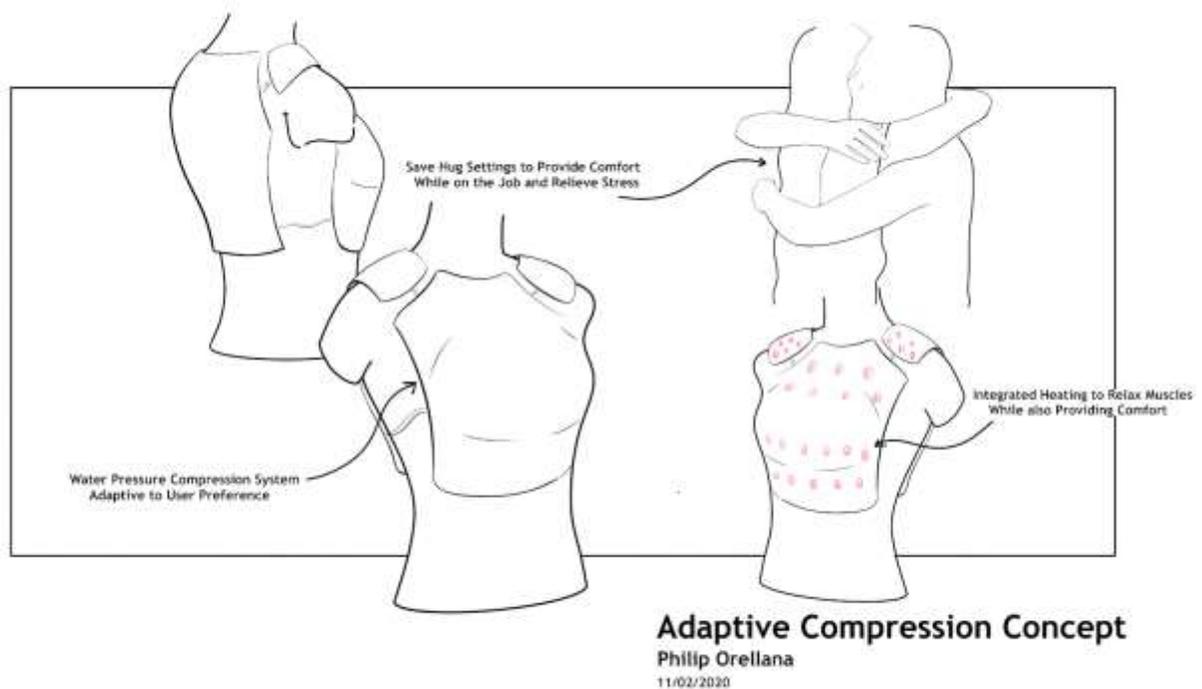


Image 6 – Image of early design thinking stage.

Participating in this process helped as new ways of thinking were able to be considered. Dealing with well-being goes beyond physical mitigation, but mental and emotional mitigation had to be considered as well in order to continue with a wholistic solution.

4.1.3 – Ideation Sketches

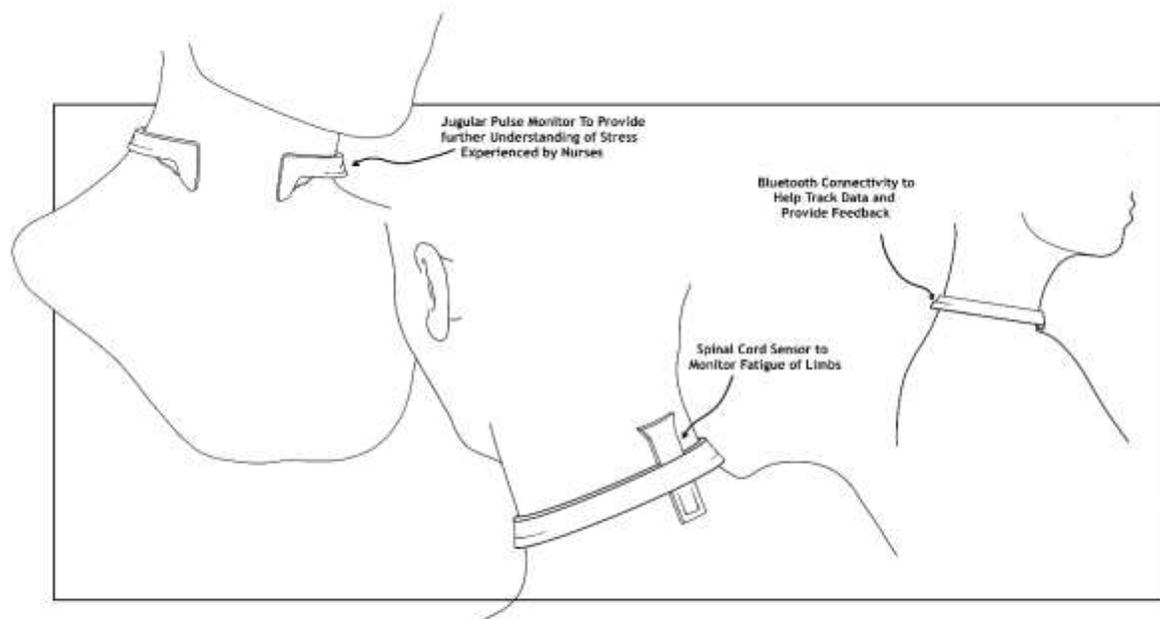
The horizons for the initial ideations were broad in order to assess the problem space from as many different perspectives as possible. It then became obvious that a focus on compression would not only help mitigate pain but also help in reducing stress felt by nurses due to the workplace setting.



« 4.2 – Preliminary Concept Exploration »

Concept 1:

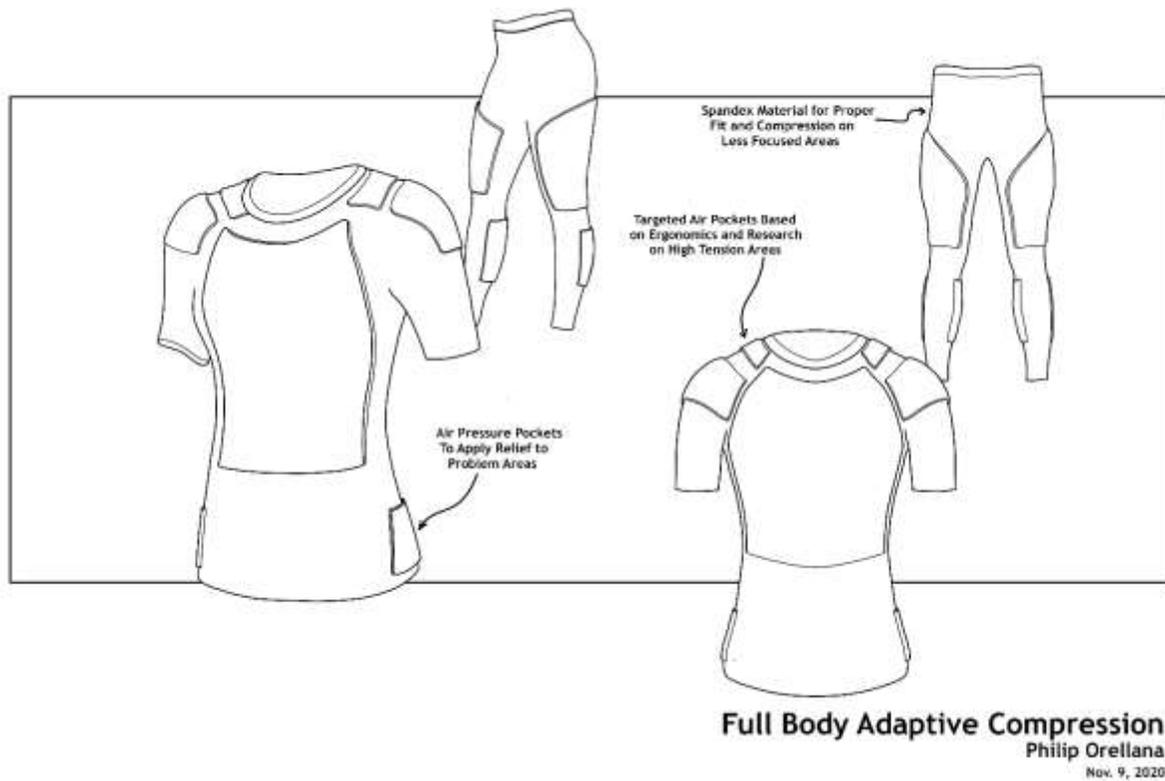
This concept stemmed from research on how often nurses are mandated and forced to continue working, despite what their level of exhaustion. The fatigue monitor was created to track an individual nurses brain waves creating a data base, in where the charge nurse can evaluate whether mandating said nurse is safe to do so or not.



Fatigue Monitor
Philip Orellana
Nov. 9, 2020

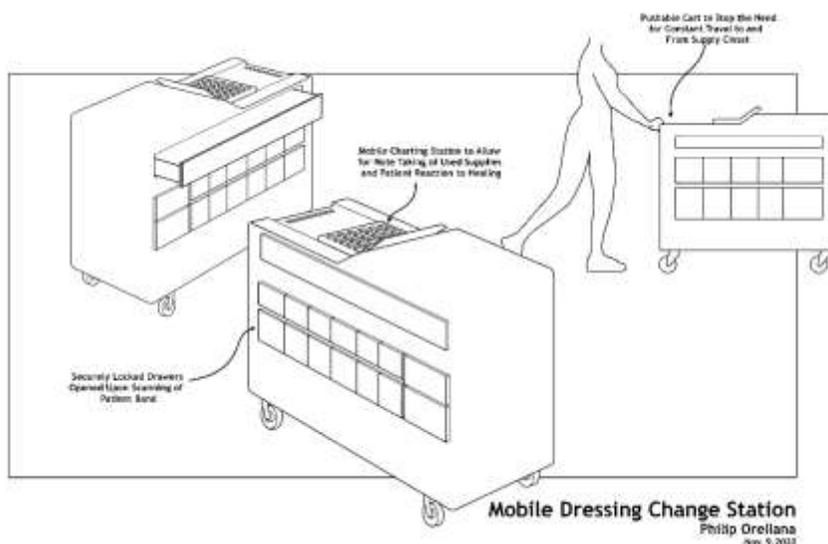
Concept 2:

This concept was based on research into the benefits of compression and how useful it can be as a source of therapy. The full body adaptive compression concept was designed to allow the user to customize their desired level of compression based on their needs and feel.



Concept 3:

The mobile dressing station was constructed from expert interviews in which dressing a patient was considered to be a highly tedious task. This concept would allow the user to travel room to room with all the supplies required of a dressing change.



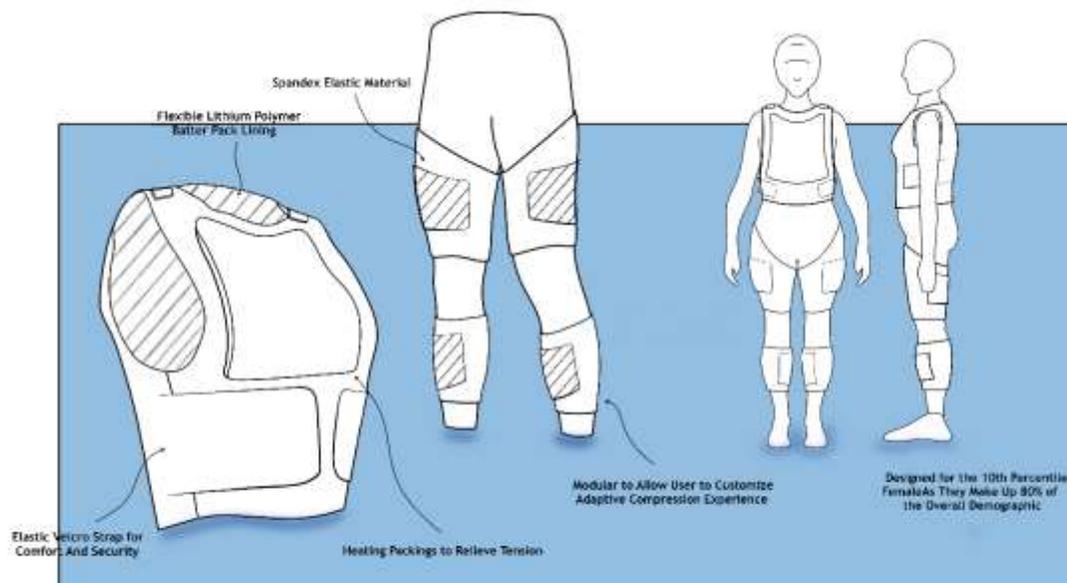
Creating these sketches helped in painting a picture of what the final solution might look like and which design to continue with.

« 4.3 – Concept Strategy »

Working in the realm of compression was the direction this thesis decided to take on. Incorporation such led to the development of this thesis, which in turn rose new questions of compression type and how to incorporate these ideas onto the body. The strategy behind each of the concepts below was to innovate a compression product that has never been seen before and to do so across a large majority of the human body. The concepts were considered as possible solutions;

Concept 1:

This concept was a further development of the its predecessor as it introduced an aspect of modularity for further customization. The modules were designed to be placed on spots of pain and soreness commonly found throughout the body.



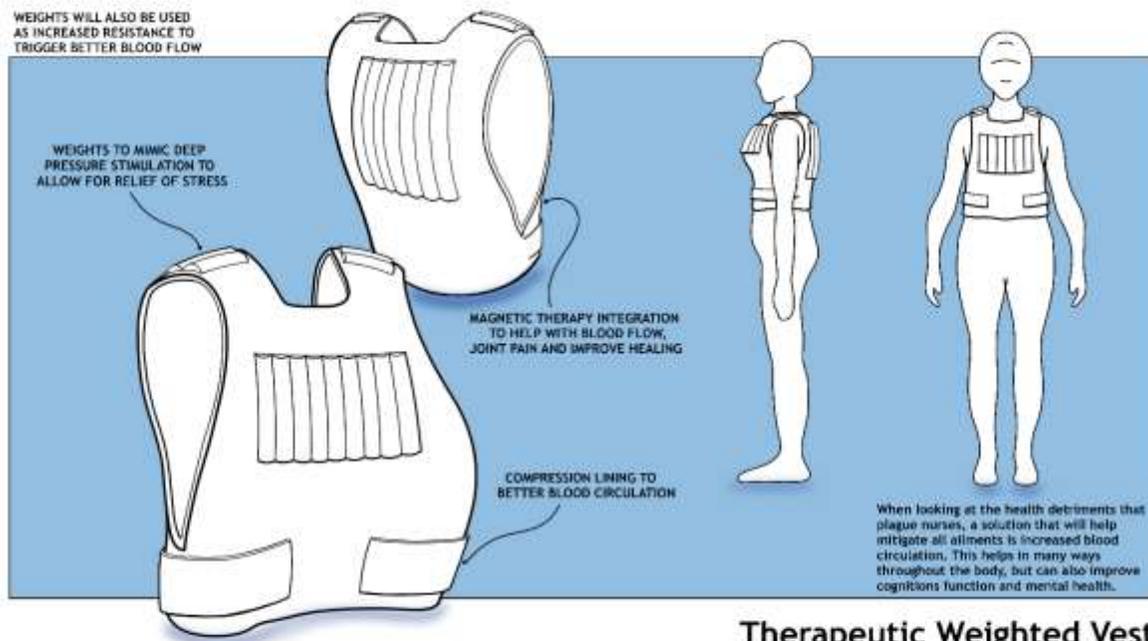
Modular Adaptive Compression

Philip Orellana

Nov. 23, 2020

Concept 2:

This Concept stemmed from research done in magnetic and weighted therapy. These approaches were combined in an effort to level users equilibrium and lower stress as both were known benefits of such therapy styles.



Therapeutic Weighted Vest

Philip Orellana

Nov. 23, 2020

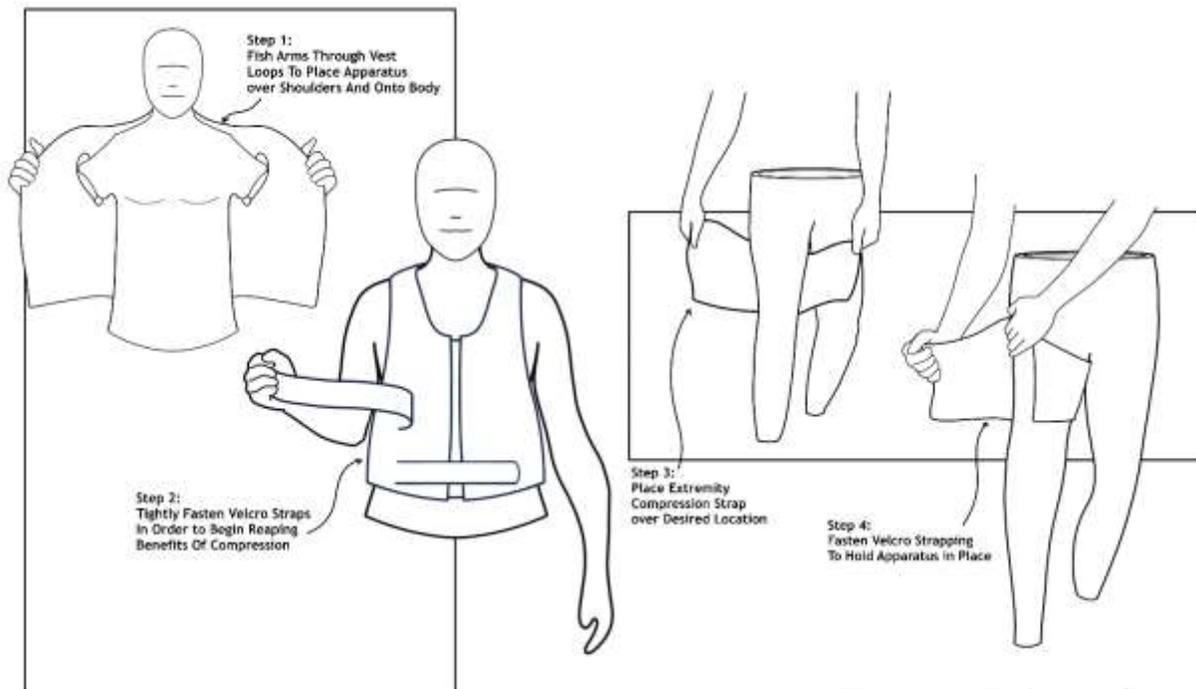
Configuration Diagram:

The chart below is a breakdown of each concept and how each would be laid out in terms of schematics.

Philip Orellana IDSN 4002 FTA-10 Selected Concepts Strategy & Product Schematics		Nov. 23, 2020 Catherine Chang/Sandra Zaccaro
Configuration 1	Configuration 2	Definition/ Explanation
<p>Front View Side View</p>	<p>Front View Side View</p>	<p>Configuration 1 Components</p> <ul style="list-style-type: none"> - Battery Pack - Air Compressor - Adaptive Air Pocket - Elastic Compression <p>Configuration 2 Components</p> <ul style="list-style-type: none"> - Magnetic Weight - Elastic Compression - Textile Body - Electro Conductive Lining <p>Location of Components will be effected by the following:</p> <ul style="list-style-type: none"> - Ergonomics - Functionality - Work Flow
<p>Front View Side View</p>	<p>Front View Side View</p>	<p>Configuration Diagram:</p> <p>These diagrams depict the possible location of the previously mentioned components. Their location is subject to change as further user observation will help workload ergonomics, functionality and workflow. This will help in the development of a possible product that will integrate easily into the nursing work environment.</p>
<p>90th Percentile Male 5th Percentile Female</p>	<p>90th Percentile Male 5th Percentile Female</p>	<p>Ergonomic Diagram:</p> <p>For the purpose of this exposition two opposite ends of the spectrum were analyzed. The 90th percentile male and 5th percentile female were used to perform an ergonomic analysis of three configurations. This allows for a wide range of body types to be considered in the preceding concepts.</p>

« 4.4 – Concept Refinement »

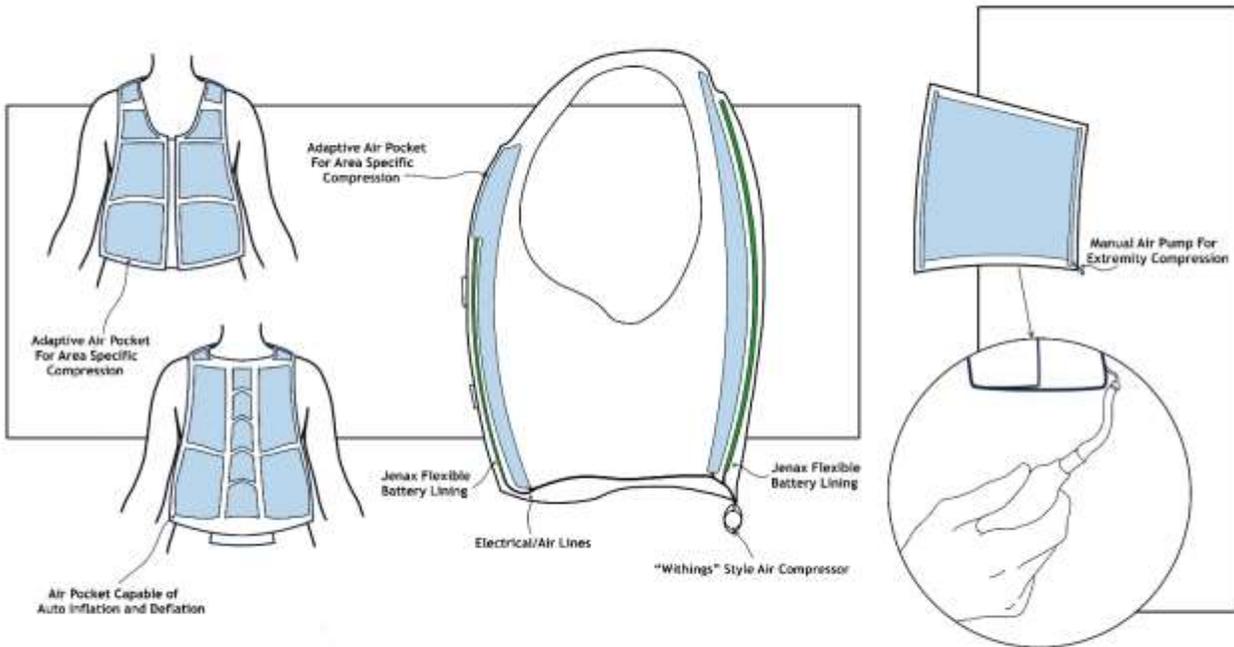
The majority of the development of the concept was done using Sketchbook Pro in order to rapidly experiment with changes in shapes, lines and colours. The form development continued throughout the duration of the thesis period as the design language was ever changing. The suit was to be complimentary of the female figure while also not interfering with the end user's movement and mobility in the workplace.



Human Interaction

Philip Orellana

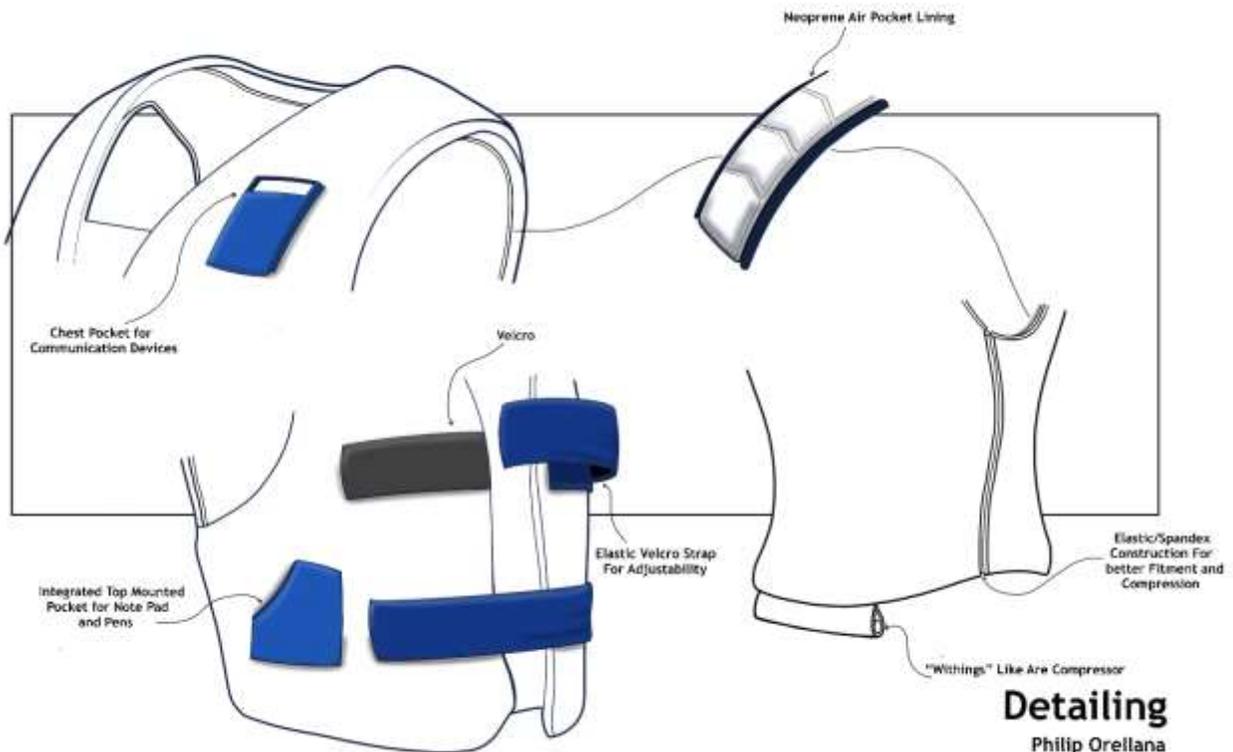
Dec. 7, 2020



Functionality

Philip Orellana

Dec. 7, 2020



Detailing

Philip Orellana

Dec. 7, 2020

After completion of these sketches, evaluation was able to be conducted, that directed the purposeful choices this thesis had to incorporate.

« 4.5 – Design Realization »

4.5.1 – Physical Study Model

A 1:1 scale model was then created. It was here that the fit and form were tested as to inform the final design direction. The model was made specifically for the 5th-50th percentile females as they make up the majority of the target demographic. A key take away in this experimentation was that the initial measurements were incorrect as head cutouts and other essential design aspects were neglected earlier in the model making process.



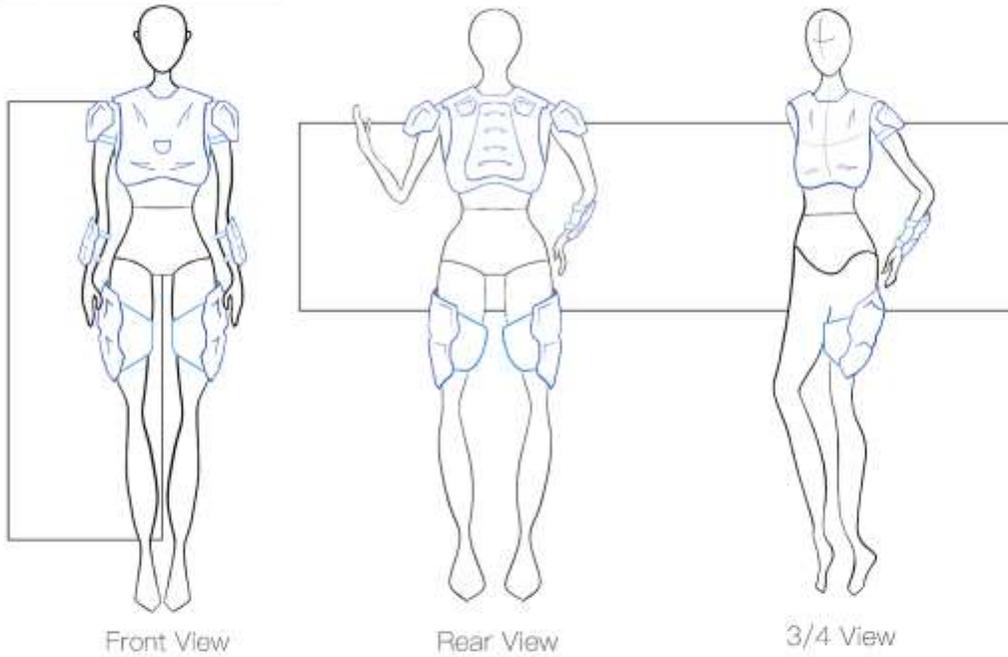
Image 7 – These images are photographs taken of the rough mockup model.

Upon concluding the physical mockup models, a few changes had to be made not only to the fit but also the form as well. The model looked quite reminiscent of motorcycle gear, which in turn would take away from the appeal to the desired target market.

4.5.2 – Product Schematic

Utilizing the lessons learned in the making of the mockup physical model, a better understanding of human interaction was able to be made. Gauging the full body interaction a revised product schematic was formed to strengthen the ergonomic appeal for the end user.

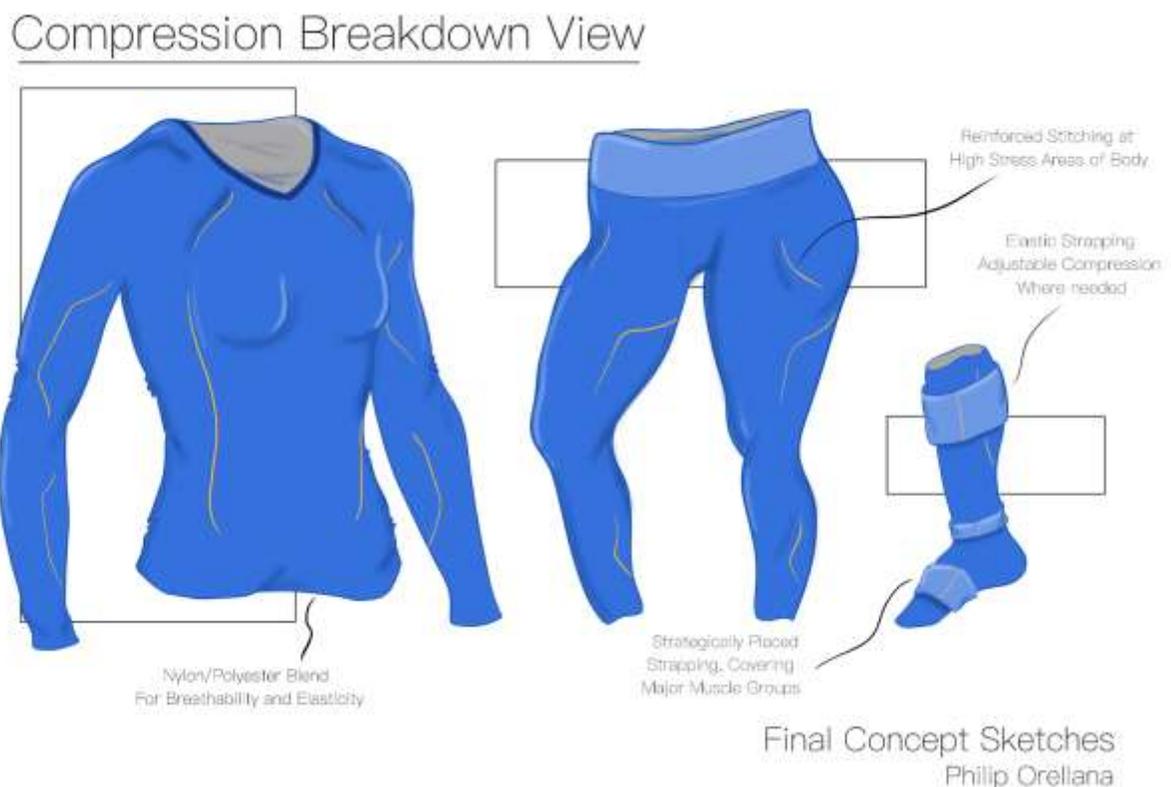
Model Views



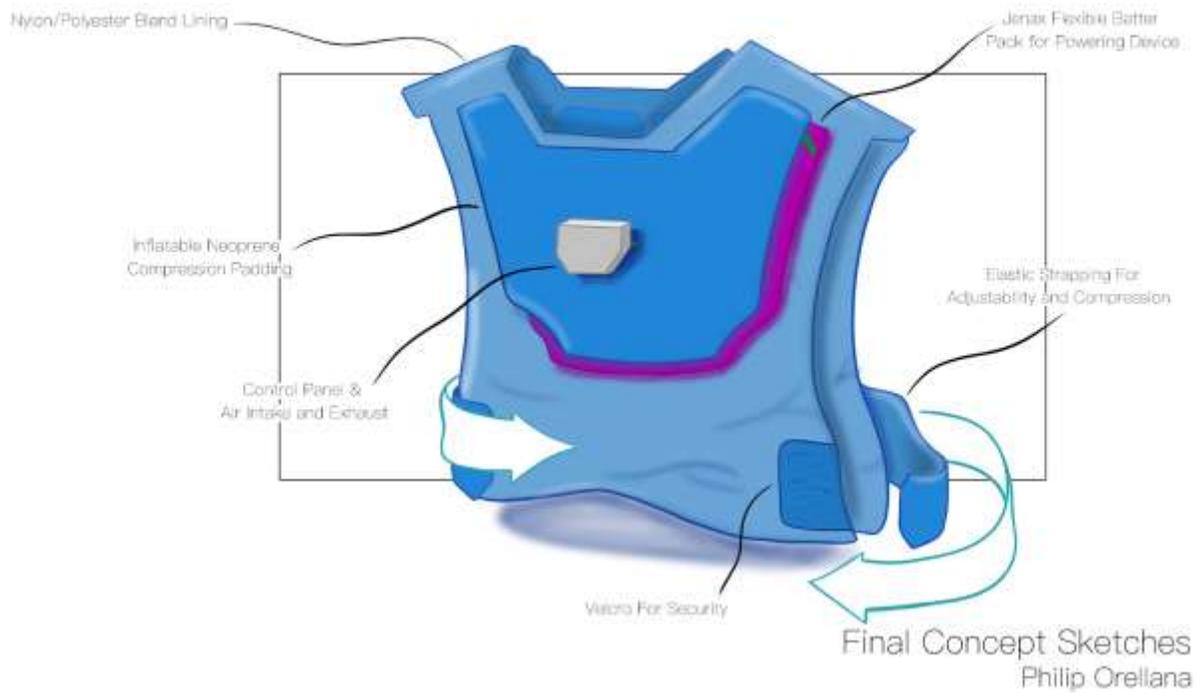
Final Concept Sketches
Philip Orellana

« 4.6 – Design Resolution »

The final design is resolved in that all aspects of design had been assessed and modified to meet the needs of the target demographic. The final design included soft and complimentary contour lines benefiting the aesthetic appeal of the female form. Human factors had also been considered in movement restriction and comfort. Such considerations determined what materials were utilized as to be purposeful with the selection. Finally, compression and technology applications were further developed as to increase any potential benefit to the end user. A large amount of information gathered was used in the final design to inform any/all decisions that had been made.



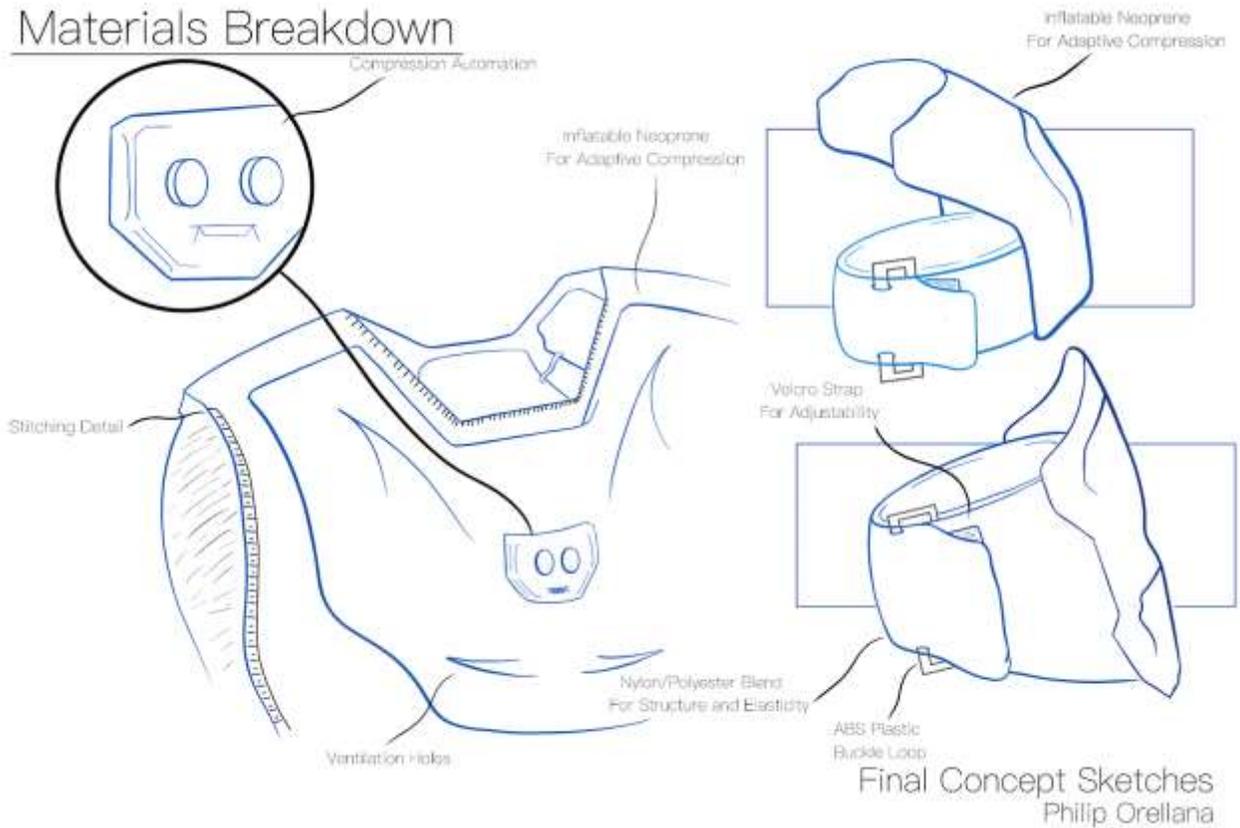
Exploded View



Detailed View

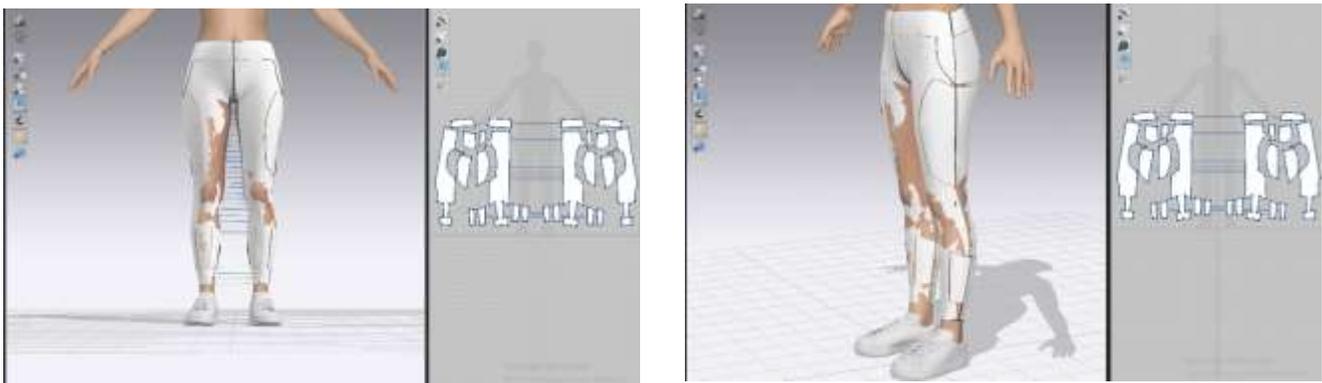


Materials Breakdown

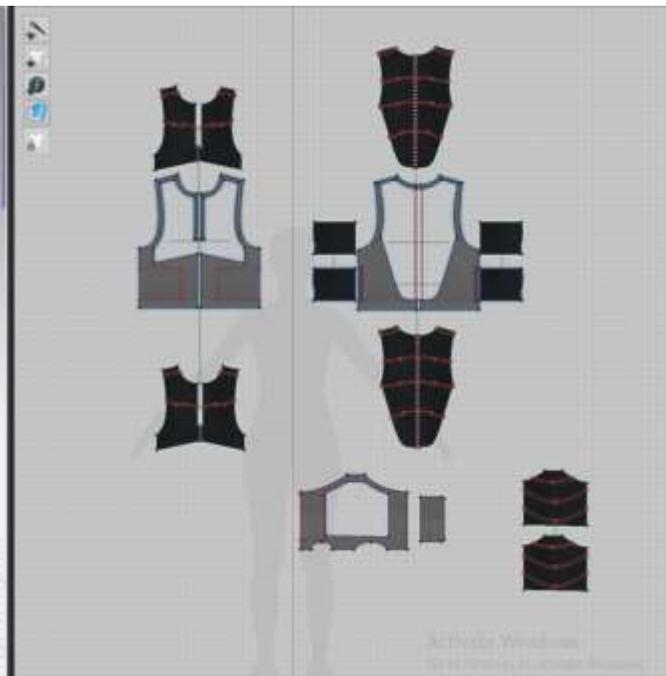
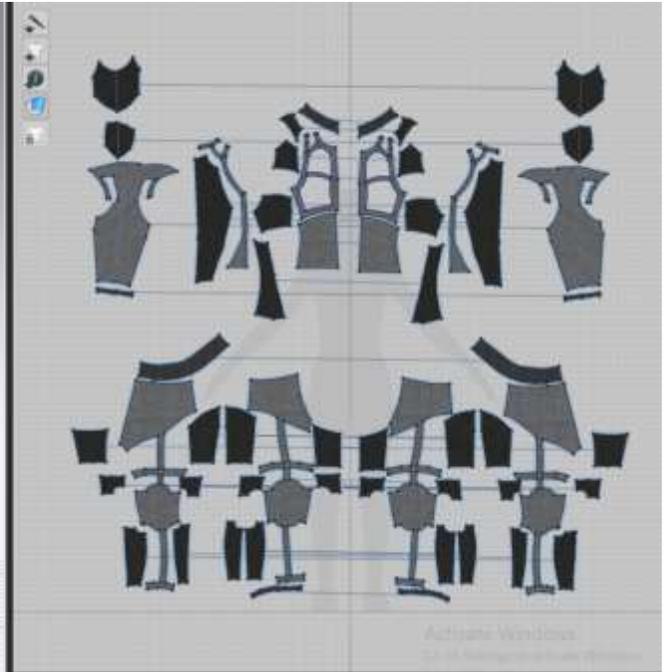


« 4.7 – CAD Development »

CLO3D was the main program used in the development of this thesis project. CLO was chosen as it is tailored to soft good design and has extravagant rendering capabilities for materials and their behaviours. Below are images of the CAD development process displaying both a 3D model as well as a 2D pattern.









Utilizing CAD to its full potential the model displayed in the images above are all completed in 1:1 scale using the same materials as in the real world. Through rendering, a near perfect visualization of what the final product will look like is possible.

« 4.8 –Physical Model Fabrication»

This model was constructed in two locations. A pattern maker helped in creating seam allowances as well as designing the finishing (hem work and buttonhole slits). The model was then constructed using a sewing machine and other basic tools.



Figure 5 – The gathering of the materials that would be used in the fabrication of this thesis model was the first initial step.

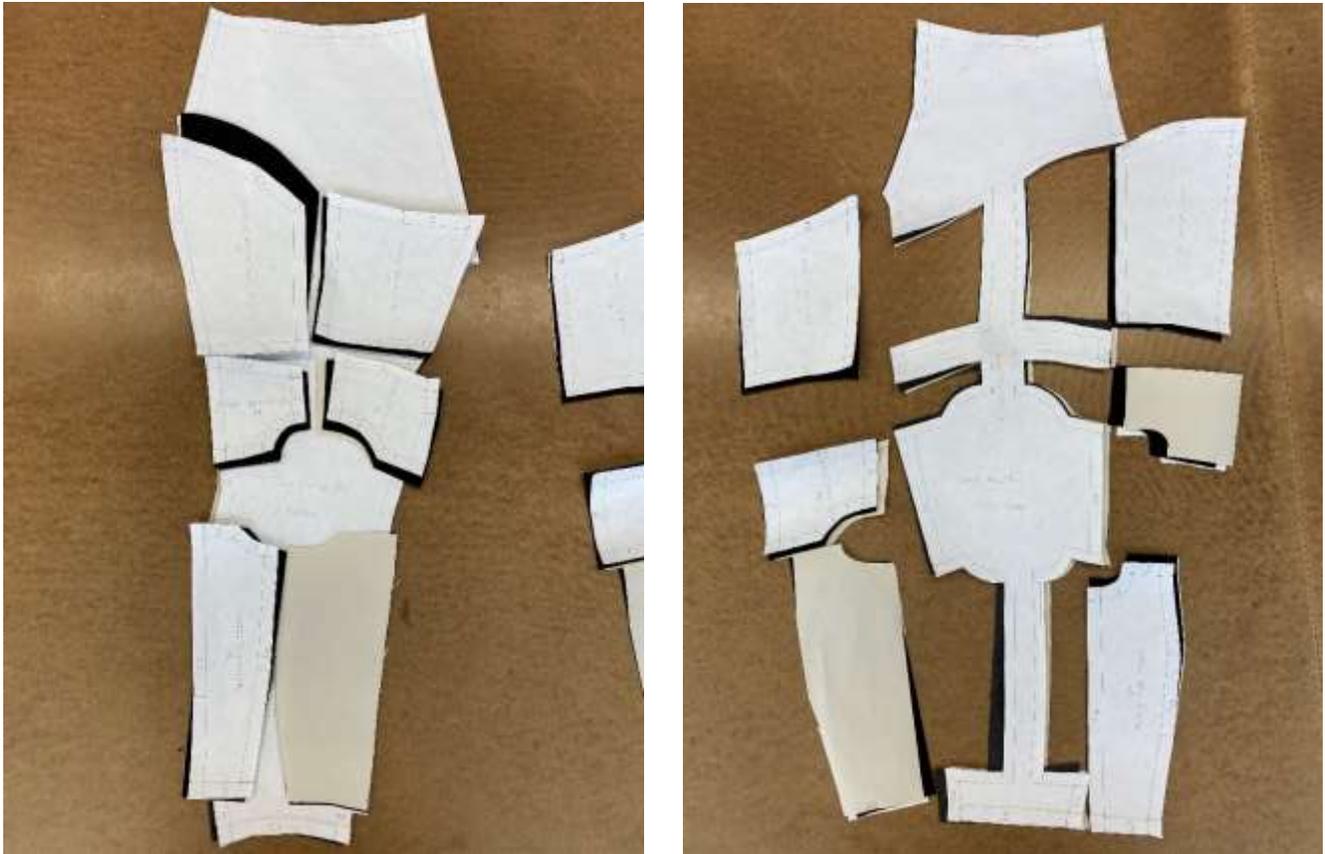


Figure 6 – Cutting and making sense of the pattern was the next step in the building of this thesis project. This allowed for the assembly process to go smoothly, as there was no guessing at the machine.



Figure 7 – With all the piecing being cut, assembly was quick, as stitching and surging was done to ensure the strength of the each model component.



Figure 8 – A final examination of the model was conducted to assure that the physical model was accurately representative of the model created in CAD.

Chapter #5 – Final Design

In this chapter the final design outcome will be summarized. It will highlight the entirety of the thesis project from manufacturing to cost breakdown and will feature visual representations of the final scale model as well and photorealistic CAD renders.

« 5.1 – Summary »

Description

I.C.A is a revolutionary product that seeks to benefit Nurses in the high stress care system environment through compression. This product combines traditional forms of compression with a new capability of adaptation and customization. I.C.A seeks to mitigate all detriments of the nursing job description increasing the overall well-being of this specific population.

Explanation

Currently nurses are often subject to overworking while being under compensated in today's healthcare system. Nurses being neglected by this system has led to an increase in health detriments associated with their job description. Nurses have very little choice for self-therapy. Current compression and pain alleviation solutions neglect the variation in degree/level of pain. These solutions are also often take a single prong approach as they seek to mitigate only one specific type of detriment.

I.C.A takes a wholistic approach and aims to alleviate all common health detriments linked to the nursing field. The *Intelligent Compression Apparatus* uses a multitude of muscle electrode sensors, strategically placed in highly used muscle groups throughout the body to monitor fatigue and automatically apply pressure to the target area. This product also employs the use of connectivity allowing the user to customize the level of compression to fit their level of comfort. Compression is applied using embedded air pockets which are then inflated and deflated with a small motor similar to portable blood pressure monitors that are currently on the market today (ex. QardioArm). Utilizing the I.C.A system will not only lower the risk of work-related injury, but also reduce stress and the risk of burnout/exhaustion.



Benefit Statement

The Intelligent Compression Apparatus is an undergarment designed to be worn throughout the duration of any given work-day. It offers improved comfort as well as better support to reduce work related stress and fatigue. This benefit is made possible through adaptive compression that increases blood flow/circulation, which is linked not only to pain relief but also in reducing inflammation and stress. I.C.A. will put the healthcare system back on track.

« 5.2 – Design Criteria Met »

5.2.1 – Full Bodied Interaction Design

I.C.A. is a piece of undergarment wear that would be sold in a variety of sizes in order to accommodate all body types. Due to the nature of compression wear, this product is meant to be skin tight, in order to perform its purpose as efficiently as possible. The nurse's scrubs are meant to worn over I.C.A as a protective layer from external bodily fluids often associated with the job. This garment will be machine washable in order to remain convenient as possible for the end user.

The adaptive components will be treated as one size fits all as they are highly adjustable, with Velcro elastic strapping to fit all body types. This adjustment will allow for ease of don and doffing while adding to the adjustability and customization of fit. The modularity of this system also allows the user to place such components wherever they feel they need, covering major muscle groups throughout the body.

I.C.A.'s most revolutionary achievement is its adaptability through the implementation of motorized expandable air pockets. While working, the adaptive compression components remain dormant until electrodes sense muscle fatigue and pain past a user specific threshold. Once pain, fatigue or stress is felt, the air pockets expand in correspondence the electrode. Not only does this reduce any pain being but it also increases blood circulation which is linked to destressing.



5.2.2 – Materials, Processes and Technology

Due to the fact that I.C.A. contains multiple layers in order to operate effectively, the materials chosen were specifically selected to serve the purpose of breathability, while remaining durable. Breathability is key to comfort as the nature of this product is an undergarment and external layers must be worn alongside it.

Materials

Vest/Limb Compression

The vest and limb compression components of this thesis project will be constructed using rPET otherwise known as recycled polyester. Recycled polyester is a sustainable selection as the fibre is made from single use plastic (bottle, wrappers, containers, etc.), keeping these plastics out of landfills and the ocean, in turn creating a wearable garment. Not only does this material reuse single use plastics, it also utilizes a more energy efficient process in its production, using 59% less energy when compared to its virgin equivalent (Elven, 2018 <https://fashionunited.uk/news/fashion/how-sustainable-is-recycled-polyester/2018111540000>).

Compression Undergarment

The underlying compression garment will be made of Vita a sustainable techno-fabric that provides breathability and muscular compression which are vital to the design. Vita is made from ECONYL which is made from 100% recycled nylon and is 100% recyclable. The company Aquafil, the producers of ECONYL state that the production of such fabric yields 80% less Global warming emissions when compared to the virgin Counterpart (Mimic, 2020, <https://ocean-mimic.com/sustainability/recycled-plastic-fabric/>).

Inflatable Air Pockets

Due to the fact that this thesis involves a form of adaptive compression, inflatable air pockets will be how this system achieves such. These air pockets will in turn be made from Repreve, a highly durable strain of recycled polyester. Repreve is

made from polyethylene terephthalate (PET) which includes reusing plastic bottles in its production. Repreve continues its eco-consciousness through the fact that the processing avoids 517 million kgs of CO2 emissions (Repreve, 2021 <https://repreve.com/discover>).

Electronic Components

All electrical components will be made using Grepow technology. This company has flexible battery solutions that are as thin as 0.4mm which serve an extremely important purpose in the powering of this apparatus. This company also specializes in rechargeable technologies, making a longer lasting battery as well as one that requires less charging time. This results in an environmentally friendly benefit of batteries remaining out of landfills and less energy to charge such. (Grepow, Unknown, <https://www.grepow.com/page/ultra-thin-battery.html>).

Processes

As I.C.A. is a wearable containing 85% soft goods material, this product will be manufactured using a common assembly line system, due to the fact that the use of new innovative materials limits the construction process. A cut-and-sew method will be employed alongside the assembly line as the garment is infused with different sensors and technology that has not yet been automated. The construction of this garment will be done in its majority by hand. However, with the electronic components being simplistic and readily available the introduction of automation will be brought in. These electronic components also have the option of being outsourced in order to reduce the overall cost of the garment.

Technologies

The majority of I.C.A.'s technological success stems from the incorporation of intelligent materials.

Each material was chosen based on their application and ability to serve multiple purposes. This product also combines soft goods, with electronic components in order to function correctly. Flexible batteries as well as small air compressors have not only brought compression to life, but also into the 21st century. These 2 main technologies allow for I.C.A. to be fully operational.

5.2.3 – Implementation, Feasibility and Viability

The main focus of this thesis project was to improve health and overall well-being. While solving such an issue is of top priority, the manufacturing cost has the potential to be extremely expensive.

Although this solution may be considered revolutionary the technology embedded within the product is easily found. The following is a bill of materials, as the majority of this product is made from soft goods, the cost has been broken down to price per meter in order to remain consistent with the practices of today. Any other components were broken down into per unit.

Material	Description	Cost (CDN)
Recycled Polyester (rPET)	Primary material used in adaptive compression modules	\$0.47 - \$0.84 per meter
ECONYL	Primary material used in compression undergarment	\$2.12 – \$2.62 per meter
Repreve	Inflatable plastic	\$8.73 per meter
Grepow	Flexible battery for lining of garment	\$117.00 per meter (estimation)
Vert.04.W Air Compressor	Used to inflate adaptive compression modules	\$48 per unit (estimation)

Table (8) – Bill of Materials for Manufacturing

Referring to the chart above, as well as taking into the amount of fabric used to make a single suit, each Intelligent Compression Apparatus will cost approximately \$611.91CDN in materials alone. Due to the fact that the Canadian labor laws state each individual must be paid \$14.25/hour and that each suit takes approximately 30 hours to complete, labor for a single suit will cost \$427.50CDN. In total, in order to break even the suit will have to cost \$1039.40CDN. If this were to go into production, part of the process would have to be automated in order to cut back on the amount of time spent on each suit. A possible solution would be to laser cut the fabric to size as means of automating part of the process. The price of each garment would also significantly drop if the garments were made overseas.

Taking all of the information above into consideration the garment would fall in the luxury segment and would retail between \$1100-\$1250. The profit margin for this product would be between 6% - 17%. In order for this product to be feasible and viable for the potential target demographic, subsidization would have to be created through a mutually beneficial program between the hospital and the I.C.A. company. Creating this partnership would lower cost for the end user while at the same time building clientele.

« 5.3 – Final CAD Rendering »





Images Above – Computer Aided Design renders to demonstrate form, fit and material.

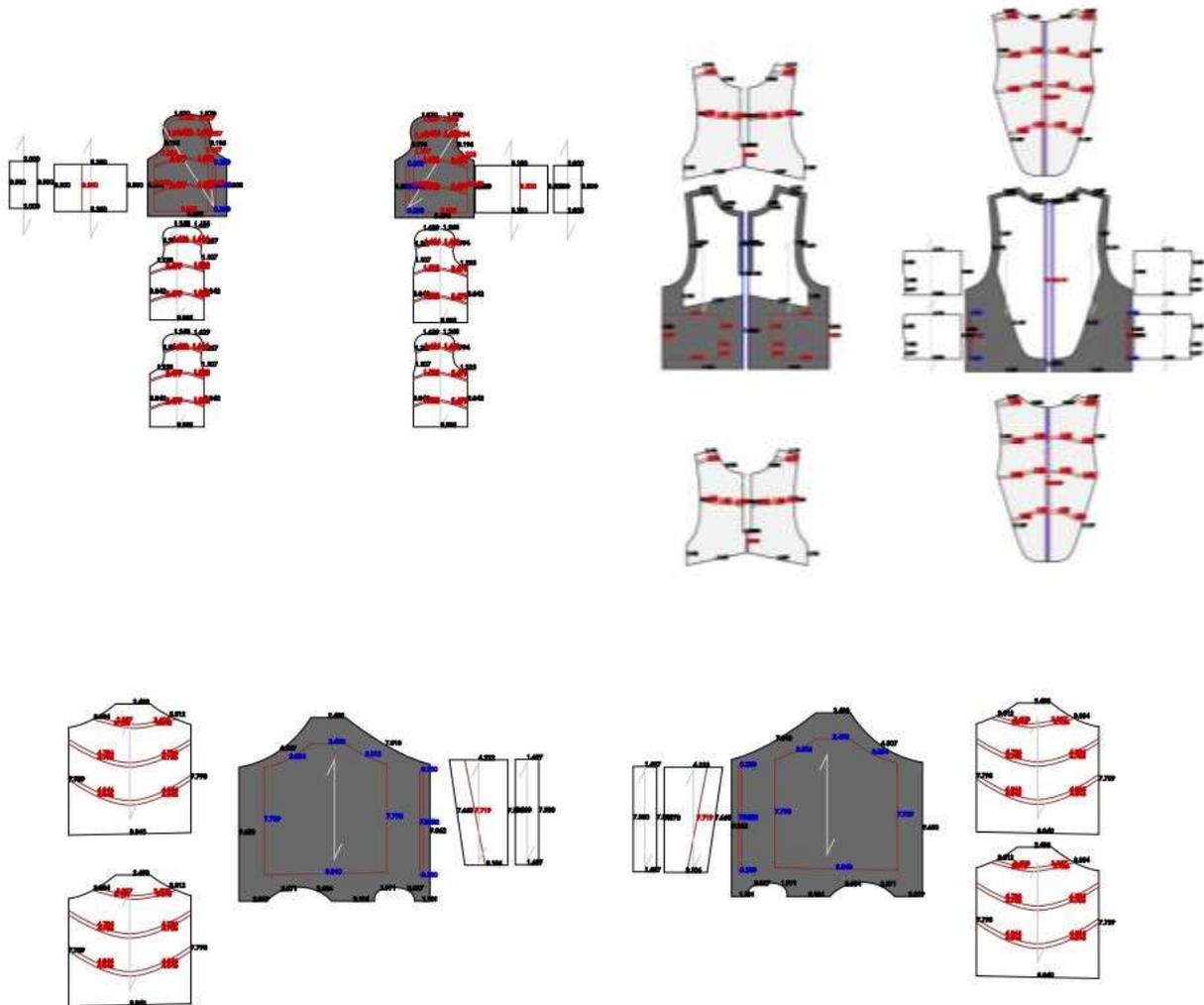
« 5.4 – Physical Model »







Images Above – Photographs of the finished final physical model.



Images Above – Final model technical drawings with accurate dimensioning and grain directions.

« 5.5 – Sustainability »

During the design process the consideration of material was a constant thought, as the design is required to be sustainable according to the thesis criteria. When dealing with the materials the purpose of each material and how it would perform the given task was the main objective, as the goal was to remain an effective therapy product whilst incorporating sustainable design elements. As far as the production practices the findings above were a happy accident, as there was no way of ensuring that

the materials selected were produced using ethical processes. As far as safety is concerned, this was of little importance, as research states, compression is not harmful to the body, even for extended periods of time. Sustainability is an important part of the design world today, and must continue to be enforced the world over.

In conclusion, the implementation of sustainability, although tedious, is necessary as the world continues to develop new ways of saving the planet. These findings must find their way into the design world, as previous generations who were not concerned with such, have doomed and damaged the globe. Sustainable design and sustainable practices, is the future, this is our salvation.

Chapter #6 – Conclusion

Currently there are little to no wholistic solutions in dealing with the mitigation of pain and other health detriments specifically tailored for nurses. Most products on the market solve a single issue/concern and fail to incorporate full bodied solutions.

I.C.A. is an innovative self-therapy system that utilizes compression to improve the overall well-being of nurses. The adaptive system sends strengthen compression to muscle groups that need it most work in tandem with a revolutionary fatigue monitoring structure. Through the utilization of compression blood circulation is improved, solving a multitude of health detriments associated with the nursing job description. I.C.A. seeks to make the healthcare system whole again by taking care of the nurses who act as a back bone to the hospital organizations.



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Appendix

Discovery

Preliminary Info Search	<p>Nurses are a neglected population that are not always taken into account when thinking about the holistic care being provided by the healthcare system. The question is; how may we improve the well being of nurses who work in bedside nursing units suffering from high stress? Nurses in high stress work environments are lacking proper mental and physical health support. With the healthcare system so focused on the well being of patients it is the health of the nurses that falls through the cracks. Nurses need a tangible design solution that addresses the detriments of the high stress work environment. Currently the solutions that are on the market mainly deal with making nursing tasks more manageable. This solution is somewhat beneficial as the physical strain of the work tasks are addressed, however they leave out the mental and emotional strain caused by the nature of the profession.</p>
Problem Framing	<p>The nursing profession is of high demand and low in funding. Nursing as a whole can easily be overwhelming as people's lives literally rest in the hands of these nurses. The job is grueling not only for the body due to long work shifts, but also extremely emotionally and mentally taxing. With nurse to patient ratios on the rise, it is hard to find free time for tasks that are as simple as going to the washroom. The health care system has neglected the health of medical practitioners and it is time to give back.</p>

Why Should We?

This topic was selected due to the fact that this problem has been occurring since the profession was established. The health of nurses has been neglected for far too long and it is time for their issues to see the light of day. It is also easy to empathize with a population that has been overlooked, with hopes to change the current status quo. Ties to the field also made this topic appealing as first hand accounts and interviews are easily accessible and can be taken into account at any given time.

User Interviews

Philip Orellana 0:01

Okay. Can you tell me a bit about yourself.

Charlene Alcaraz 0:08

Um, I am 22 years old. I am a newly graduated. Nurse. Wait, just about my nursing?

Philip Orellana 0:25

anything just just anything about yourself.

Charlene Alcaraz 0:28

Okay. Um, yes I just graduated nursing I went to a French University. I did all my schooling in French. I didn't know I wanted to pursue nursing right away. But I knew I wanted to work with babies or children. So that's where I'm at now. I am a NICU nurse, but I did my final practicum with mothers and babies in a postpartum unit. I really like kids. And yeah.

Philip Orellana 1:11

So when you say you weren't you didn't know you wanted to be a nurse. Well, what were you thinking about originally?

Charlene Alcaraz 1:24

From a very very young age, I wanted to be a pediatrician. So a doctor for kids, basically, um, but in high school. While I was researching things. I realized how much schooling. It took, and I was looking into the courses that I would need to take and kind of the route that I will need to take in order to pursue this career. And I just feel like to become a doctor to pursue medicine. You have to be someone who thoroughly enjoy school and I also think that becoming a doctor is not only choosing that career path I think that's also choosing a specific type of lifestyle. So that was something that really stood out to me. I just really didn't want to have that type of lifestyle where I'm like working all the time, especially while you're in school like in your residency like you lose a lot of time. That was like the main reason.

Philip Orellana 2:30

Okay, so you I guess you were always interested in the medical field. Yes. Okay, cool. Um, when we were talking about the packing the dressing change. Is that an activity you usually do with another nurse or is that something you typically do on your own.

Charlene Alcaraz 2:52

It honestly always depends, with larger patients. Usually we would have two nurses. Just to like hold everything up. Or like if you need to move the patient throughout the dressing change or anything. But typically, it is something you do on your own.

Philip Orellana 3:21

Okay. And how often do you. Would you say that, a dressing change needs to be addressed.

Charlene Alcaraz 3:32

And, again, it depends on the patient and their situation. But a lot of times. Let's say it's a bigger wound. And it's like, infected. Those types of dressings would likely want to say be changed. Like, at least once a shift. So once a shift could mean like three times a day. Okay. Or like at least once a day. Some dressing changes are only done every other day, but like, if you're a nurse working in a medicine or surgery unit you're performing dressing changes. Like every shift.

Philip Orellana 4:18

Right. Okay. Um, and how would you say you feel about this task.

Charlene Alcaraz 4:26

Um, well as a new nurse for sure it's something I find nerve wracking still because maintaining sterility is very important because you don't want to re introduce any bacteria and delay wound healing. Um, so it's not a task or a nursing skill that I find myself confident in or even comfortable doing per se. A lot of nurses, I think, would say the same thing like even nurses that I followed with a lot of experience. Find dressing changes, difficult so we actually have in the hospital that I work at a wound specialist. And this nurse comes in usually to do the very complex dressing changes that I guess like a lower level nurse would have too much difficulty doing so it's a hard skill for sure and personally like. I find it hard.

Philip Orellana 5:29

Okay, cool. And could you tell me a bit about the, like, how you first started doing the task let's say like your first interaction with wound healing.

Charlene Alcaraz 5:44

Like the first time I did a dressing change kind of thing.

Philip Orellana 5:47

Yeah. Yeah.

Charlene Alcaraz 5:50

So the first, if I can remember. For sure the first dressing change. I did was obviously like on a smaller wound. So it was very simple packing very similar to the packing in the video, because there's, there's actually dressing changes that are very simple it's basically like putting a bandaid on, but dressing changes with packing is what's really hard. So my first time, I remember I had a hard time. First of all, going in seeing the patient, asking them if they're comfortable with a nursing student performing the task and then, because the wound is covered you kind of have to gauge, just by looking at the outside and how big the dressing is how much supplies, you're going to need and then. Aside from that, you also go based off of whatever the previous nurse who did the dressing change documented, so that nurse documented like Oh, she used for two by twos to pack the wound or five centimeters of new gauze to pack this phone, then I would assume that it's the same packing that I'm going to use. So I found it hard to do that because it's completely covered. I was really really nervous because obviously I had somebody watching me perform the task. And the patient was also aware that I was a nursing student it was going to be my first time, not doing it on a mannequin. Um, but the part that like really gets me the most even up to now is literally just maintaining sterility. So I remember opening up the tray and literally my hand was shaking because like I said like all the trays that I've worked with they're paper tray. Paper trees I guess is what you call them, and they tend to fold back and close over the tree, which then you break sterility of the tray, then you need to start over again. So luckily that didn't happen to me. But yeah, it went pretty smoothly except I remember I had to change my gloves because I was packing the wound. And I was using a Q tip and my hand like touched the outer wound bed so like just the skin around the wound. And I had to change my gloves flustered me a little bit, but because I had guidance from my clinical prof wasn't so bad. And the patient was very supportive. And yeah, then I close it. And then I documented what I did. But it was a nerve wracking experience for sure.

What do they need to do?

Philip Orellana 8:43

Okay. Um, and let's see where we're at with interview. What motivates you, or motivated you to become a nurse.

Charlene Alcaraz 9:06

I was looking into a lot of different health careers, where I could still work with kids, or babies. So I applied into the nursing faculty right out of high school, and I also applied to the University of Manitoba. for the science faculty just in case I didn't get into the nursing. And I kind of told myself that if I got direct entry, then that was kind of like a sign for me to do it. And then in my first year of nursing, I was actually very unmotivated to continue to pursue the career. And then I did my first practicum which was basically working as a healthcare aide, which I think is called the P SW there, or something. And just the experience with helping patients and them thanking you and telling you, like how much impact you have spending time with them and helping them and care for them. That was what kept me motivated to stay in nursing. All these years.

Philip Orellana 10:34

And when back to the wound. The sorry the dressing changes, what is important to you to call the task finished. Like, like I guess how do you know when you're done

Charlene Alcaraz 10:57

when it's fully covered and everything is documented.

Philip Orellana 11:01

Okay, so I guess it's not done until you're you've charted it basically.

Charlene Alcaraz 11:06

Yeah.

What do they See?

Philip Orellana 11:07

Okay. So when we're talking about the tools and like the area that you use to do the dressing change. What does that look like.

Charlene Alcaraz 11:29

Um, I guess in some ways it's very similar to the video that we were watching. Um, but here. Usually, there is the dressing tray has like the the gauze in it already and the ones that we open up have little like pockets, I guess, where you can pour in the sterile water like kind of how you saw in the video but I think she put her syringe into like another bottle. We don't do it that way we just put it in like a little bowl that's like already within the tray. And you have to open that up Sara Lee because that's considered your sterile field, like she opened up her field on the bed. I definitely would not do that. But I think it was just for the purpose of the video, I'd open it up on the patient's side table. And then I would open up the rest of my supplies sterile Lee onto that tray. Um. That's basically it. Because like the wound care trays here. It comes with everything in it.

Philip Orellana 12:54

Okay. Yeah. Okay. Um, and what are some like important visual cues while doing the task let's say like, I don't know, for example, the patient is bleeding or is there like any, any visual cues that are important to keep in mind.

Charlene Alcaraz 13:18

Um, definitely, pain tolerance, because if your patient does like grimacing and like you notice them doing that like that can be an indication that they're one in a lot of pain and to that because they're in a lot of pain. They might start moving around and then if they're moving around a lot. You should definitely slow down give them a second, consider like a second dose of medication if that's appropriate and allowed. And to like you want to keep in mind that because they're in pain they might like if they're moving around you might break sterility. So you want to like, kind of readjust based on that, um, another visual cue. If like let's see where I was doing the dressing change because the dressing was like completely saturated with blood if it continues to bleed, a lot, and doesn't stop. Then I'd for sure. Call the doctor to assess because you don't want the patient to lose too much blood. And if there's any other like obvious signs of infections that need to be further assessed by the doctor, or that I think may need, like some sort of ointment or if the patient even needs like a special type of dressing like for example of vacuum dressing, which can only be done by certain nurses or here in Manitoba anyways, then that would be something I'd have to, that'd be a cue for me to call somebody to assess the wound.

What do they say?

Philip Orellana 15:03

Okay. Cool. So moving on. What is going on inside your head, as you are doing this task.

Charlene Alcaraz 15:21

For me, obviously like step by step the procedure and like the entire time I'm thinking in my head don't break sterility don't break stability. And also, like, I try to think of a topic of conversation that I could talk about with the patient to keep them distracted. That's basically it. Okay. And like, just keeping note of like what I'm seeing how I'm doing everything, because, like, we have to chart everything at the end.

Philip Orellana 15:51

Right. Okay, um, and what instructions Do you give others related to any part of this activity.

Charlene Alcaraz 16:03

Make sure you give your pain medication. Don't break sterility and always bring extra supplies.

Philip Orellana 16:10

Okay. And is there anything that's said to the patient beforehand.

Charlene Alcaraz 16:18

Um, basically just letting them know that you're going to be performing a dressing change, asking them if they want pain medication.

Philip Orellana 16:30

Do you ever walk them through the procedure or anything like that.

Charlene Alcaraz 16:35

It always depends on the patient like if it's a coherent patient who's like, well involved in their own care kind of thing, then usually I'll just let them know and then ask them like do you want me to walk you through the procedure while I'm doing it, or do you want me to distract you. So, not necessarily I guess.

Philip Orellana 16:59

Okay. And what type of social conversations take place when doing any of the tasks related. I guess you kind of spoke touched on that, by basically just trying to keep them distracted.

Charlene Alcaraz 17:14

Yeah, okay. Basically anything yeah that they want to talk about . Yeah.

What do they do?

Philip Orellana 17:18

okay. That's awesome. I'm sorry. Just give me one sec. Are there any steps for this task that you have to prepare in advance.

Charlene Alcaraz 17:44

Well you have to prepare the medication in advance. And you have to give that 30 minutes before you start the procedure. And then basically just gathering your supplies, before the task, obviously.

Philip Orellana 18:01

right, okay and where do you usually get your supplies.

Charlene Alcaraz 18:05

I'm usually just in the supply room. And then, if the patient has like a special type of loan or like a very complex one like the doctor will have things ordered and the patient will just have it in their room.

Philip Orellana 18:25

And that supply closet, I guess, is it all sterile. Is it like completely separate from everything else, or is there other things in that room.

Charlene Alcaraz 18:36

There's like the supply closet is usually just the designated supply closet. But like all the supplies that you use like if it's if it needs to be sterile then it's packaged to be sterile. If it's just like a clean tool that you need or supply that you need, then it'll be packaged in a clean way, but a lot of the time things are packaged sterically so that if you need it steadily, you can open it steadily. If that makes sense. Yeah.

What do they hear?

Philip Orellana 19:09

It definitely does Yeah. Can you recall any comments people have made about you doing your task.

Charlene Alcaraz 19:41

No, really like as a nursing student, obviously like the clinical prof had lots to say, regarding that like just basically giving tips, reminding me to make sure that I have this and that ready and making sure that you do it in a timely manner because like, while it is important to maintains to really like like because you're wanting to maintain stability you tend to perform the task slower, but because you have other patients to get to you have to do it still in a timely manner. So that's like a common thing and like, even in the work in there like real work field is basically the same thing like just making sure that even if you're performing like wound care, and it needs to be sterile like yes you're careful but you're still performing it in a timely manner so that you can organize your time appropriately. And other times like I know one patient that I had this was a good one actually she wanted to play music during her dressing change, because it was a very painful and very thorough adjusting change. And because we had a lot in common. And like we liked the music she was playing, and I gave her like a good dose of pain medication like she had said that it was like the most comfortable dressing change he had so that was a good comment.

Philip Orellana 21:10

Okay, that's good. I guess. Could you describe any important auditory cues while doing this task.

Charlene Alcaraz 21:27

Auditory.

Philip Orellana 21:28

Yeah, like anything that you can hear basically.

Charlene Alcaraz 21:33

Um, basically just if the patient is like verbally complaining or grunting or any of that would be an auditory cue but there's not really any auditory cues in dressing changes.

Pains

Philip Orellana 21:52

Okay. And is there anything that you find difficult about doing this task.

Charlene Alcaraz 22:09

Um. Personally I just think, like, dressing changes with packing are is just difficult in general. Yeah, but I think the most difficult is like staying sterile the whole time. Without going so slow. Yeah.

Philip Orellana 22:38

What gives you the most grief or frustration, while doing the task.

Charlene Alcaraz 22:48

the supplies the supplies stuff I'm using yeah because like yes there's a lot of stuff that you can grab and use but sometimes like you don't take enough into the room or you anticipate something different and it's not right for the wound, and like, Even if you have all the right things, because it's such a sterile procedure, like, like for example like when I said if you're packing a narrow wound. The q tip yards, pretty small. What if the wound is that narrow like. It's basically impossible to maintain sterility and packet the way it needs to be.

Philip Orellana 23:31

Okay. And something that you said jumped out at me was, you said if you don't bring enough supplies into the room. What happens in that situation.

Charlene Alcaraz 23:45

Um, well, you cannot turn your back from your sterile field. So, basically you cannot leave the room to get more supplies, unless you're just going to like start over again, like a reopen up a new train reopen up everything that you were using. So you can just like, take off your sterile dogs and call someone like use a call system from the room to call another nurse or whoever, to grab a few more supplies so that you can at least stay in the room and watch your sterile field and watch, stay with their patient and not leave them open alone. That's like the best way to go but if every other nurse is busy and you can't do that then, like, you're kind of out of, you're kind of out of luck you have to restart and go grab more supplies. Okay.

Gains

Philip Orellana 24:45

Is there anything enjoyable about the task?

Charlene Alcaraz 24:57

the satisfaction of doing a Could I guess if you do it good, but not really not any I can think of.

Philip Orellana 25:04

And how would you know you did a good?

Charlene Alcaraz 25:10

Um, like you covered the entire wound bad like for if you're packing a wound, you cover the entire wound bed. And then you're like overall cover or bandage I guess, of the dressing is like not over the tape it's clean, it's flush to the skin. And like most of all the patient is comfortable with the dressing.

Philip Orellana 25:34

Okay. So I guess it's it's basically like feedback that you get from the patient then?

Charlene Alcaraz 25:42

um, yeah kind of an also that like you should be packing like let's say it was a dressing with a lot of saturation, like you should be packing the dressing enough that like it's not going to seep through right away unless it's like, like, obviously if it's seeping through that quickly that much. And there's something wrong with the wound and the patient but, like, Yeah, like you know it's good if it's if it stays in place if it doesn't come off right away. And yeah, the patient is satisfied. I don't know if that made sense.

Suggestions and thoughts

Philip Orellana 26:23

No, it did. Yeah. Is there anything that would make the task more productive. Or, I guess, more efficient. In this sense.

Charlene Alcaraz 26:55

I guess I would just be nicer, like the dressing tray and like the supplies are like more accessible. Obviously, be nice if you had like another pair of hands but that's not always something you can have, right, because other nurses are busy but yeah like I personally just like it's hard as is to stay sterile while you're actually packing but then to worry about like, just simply opening your supplies and staying sterile in that sense like I feel like that's unnecessary there's gotta be a way to make it easier in that sense.

Philip Orellana 27:44

And is there anything that would make the experience more enjoyable for you. More so while you're doing the task, not so much like afterwards.

Charlene Alcaraz 28:04

Like, other than a co operative patient, and I can't think of anything. Okay.

Philip Orellana 28:11

And that is all I have for you.

Charlene Alcaraz 28:15

Thank you.

Philip Orellana 28:16

Thank you.

User Research

Abstract

Bedside nursing is stressful and tiring work, the nurses functioning within this job description makeup a large amount of the healthcare system. Nurses play a vital role in the overall well being of a community, treating the ill and rehabilitating them to once again join the working society.

Unfortunately these caregivers are neglected within the healthcare system as stress, sleep deprivation and other mental and physical ailments plague them. To further the understanding of this demographic,

this report seeks to construct a user profile of the average bedside nurse. The three main demographics identified include; ICU nurses, nurse educators and patients. Information in regards to how these users look and other introductory knowledge will be accumulated through use of an image search. Literary notes will also be collected to further the understanding of the target demographic and how they behave.

User Demographic

The target market was identified as information such as age, gender, ethnicity, income/purchasing power, and education were sought to deepen the knowledge of the demographic.

Search Method

Google was the sole source used in discovering what the average nurse looked like, specifically bedside nurses for the purpose of this assignment. The search terms used in finding the desired outcome are the following:

- “Bedside Nurses”
- “ICU Nurses”
- “ER Nurses”
- “Med Surg Nurses”
- “Nurse Educator”

Image Search Findings

Image	Findings
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 <p><i>Figure 1 - Paula Trabucco, RN, Retrieved from https://bwhpublicationsarchives.org/DisplayNurse.aspx?articleid=1260</i></p>	<p>Age: Early to Mid 50s Gender: Female Ethnicity: Cocasian Income: Unstated Education: Bachelor's Degree</p>
 <p><i>Figure 2 - Intensive care unit at Cleveland Clinic Marymount Hospital, Retrieved from https://www.ideastream.org/news/postcards-from-the-pandemic-cleveland-clinic-icu-nurses-covid-stress</i></p>	<p>Age: Early 20s - Mid 30s Gender: Majority Female w/ 1 Male Ethnicity: Cocasian Income: Unstated Education: Bachelor's Degree</p>
 <p><i>Figure 3 - Med Surg unit at St. Francis retrieved from https://stfrancisheartcenter.chsli.org/press-fourth-med-surg-unit-st-francis-receives-top-honor-nursing-excellence</i></p>	<p>Age: Mid 20s - Late 50s Gender: Female Ethnicity: African American, Cocasian, Middle Eastern, East Indian Income: Unstated Education: Diploma & Degree</p>

Literary Search Findings

A combination of searches utilizing Google and the Humber Library were used to find analytical data best representing the chosen demographic. Similar search terms were used, however more specific language was used to find the desired results. The terms include the following:

- “Average age of bedside nurse”
- “Dominating gender among nurses”
- “Nurse cultural demographic”
- “Average nursing income”
- “Nursing education statistics”

Age

According to the Allied Staffing Network, the average age of nurses is on the rise as the majority of the workforce resides in the 50 and over age range. A study shows that the average age of those becoming Registered Nurses is 30 and that 75% of the nurses will be retiring by 2050, leaving extremely big shoes to fill within the healthcare system. Figure 4 demonstrates this trend within Canadian

provinces.

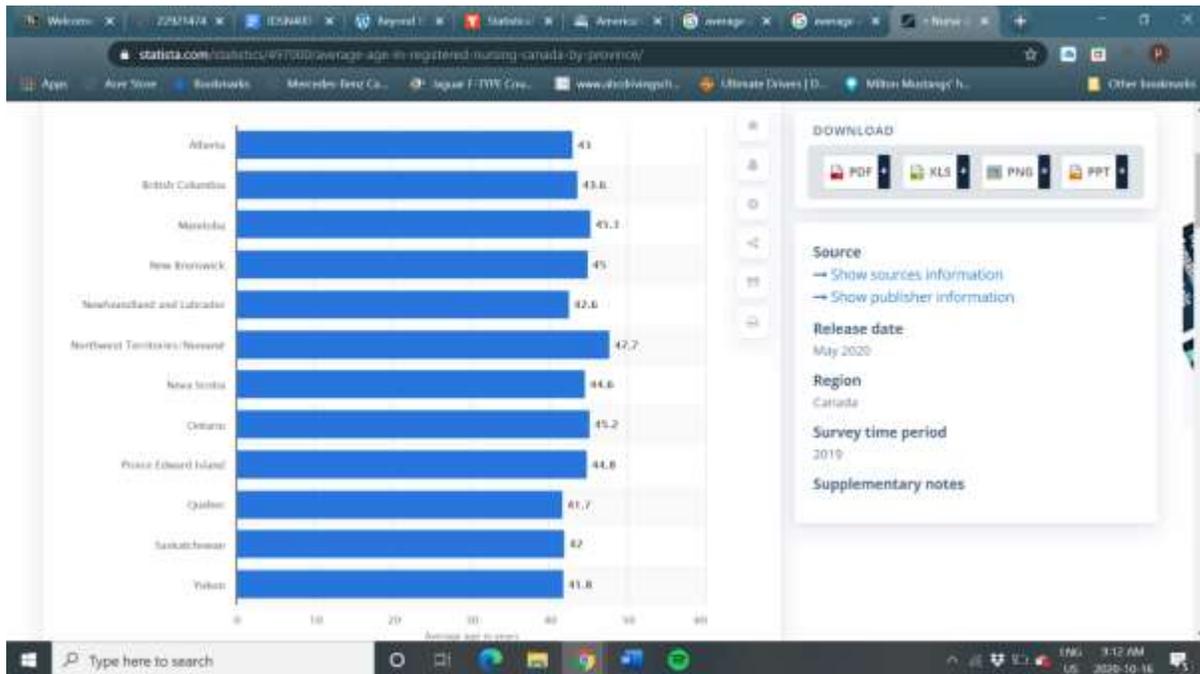
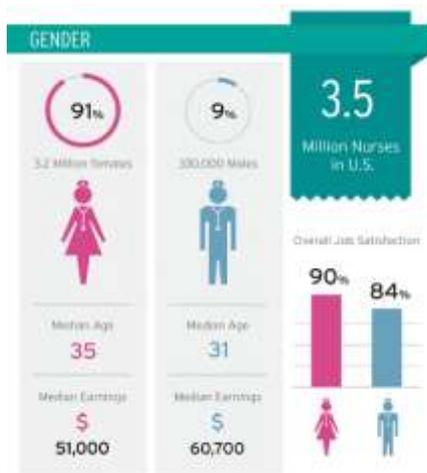


Figure 4; Average Age of Nurses Within Canada retrieved from <https://www.statista.com/statistics/497000/average-age-in-registered-nursing-canada-by-province/>



Gender

The nursing industry predominantly consists of women. Men are largely outnumbered as a 2015 census has shown that they make up approximately 8% of the nurse population which has only increased by a mere 1.1% since then. Figure 5 depicts the dominating gender amongst nurses within the U.S.

Figure 5; Gender Separation within Nursing Industry
retrieved from <https://www.pinterest.com/pin/605241637394893192/>

Race and Ethnicity

Upon further investigation of the nursing demographic, minorities make up a small portion of the workforce, with the caucasian ethnicity dominating the segment. Accordingly the caucasian nurses make up 80.8% of nurses and the remaining 19.2% are of visible minority cultures. Interestingly enough this trend seems to vary depending upon location, having some areas oppose these statistics.

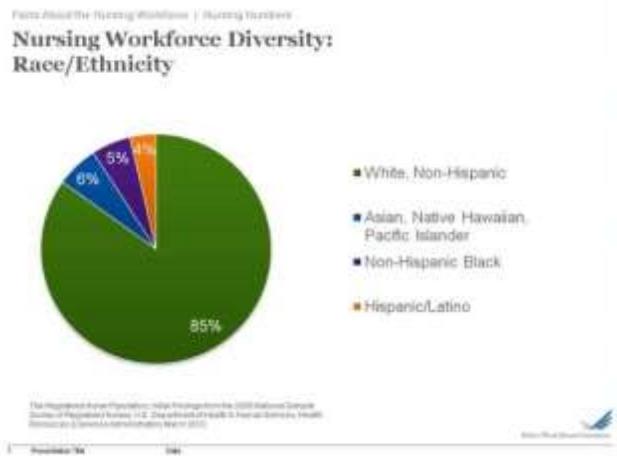


Figure 6 visualizes this data within America.

Figure 6; 2008 Census of Diversity within Nursing Industry

retrieved from https://www.mghpcs.org/eed_portal/EED_diversity.asp

Income & Earnings

When looking at income Nurses like other occupations, experience leads to greater wage earnings. However wages are also affected according to location, with Manitoba and Alberta making noticeably more than other provinces. Unfortunately statistics related to the percentage of those making a specific income is unavailable. This information would pose useful as it would help understand how many nurses are earning a decent income, as salaries range from 32\$/hr to 42\$/hr. Figure 7 shows average earnings according to location within Canada.

Average (Median) Hourly Wages for Registered Nurses in Canada

Location	Hourly Wage	Hourly Wage	Hourly Wage	Year
Calgary - Alberta*	43.81	43.81	44.33	2017
Edmonton - Alberta*	42.81	42.81	43.64	2017
Vancouver / Lower Mainland Southwest - British Columbia	32.83	36.71	43.97	2016
Winnipeg - Manitoba	33.25	35.05	42.23	2016
Fredericton / Oromocto - New Brunswick	37.05	36.00	42.33	2016
Halifax - Nova Scotia	39.38	38.00	42.00	2016
Toronto - Ontario**	32.00	35.00	45.00	2016
Ottawa - Ontario	32.00	35.00	43.81	2016
Windsor / Sarnia - Ontario	38.24	35.00	45.00	2016
Norfolk / Niagara Peninsula - Ontario	32.00	35.00	45.00	2016
Prince Edward Island	32.15	35.63	40.25	2016
Montreal - Quebec	31.36	31.00	39.48	2016
Saskatoon / Regina - Saskatchewan	32.00	45.00	49.93	2016

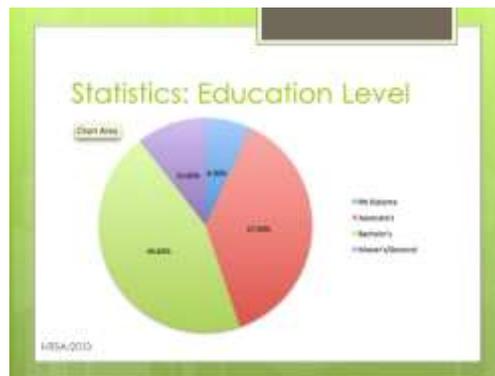
Figure 7; Average Wages for Nurses in Canada

Retrieved from <https://www.inscol.com/canada/blog/things-you-must-know-about-working-as-a-registered-nurse-in-canada/>

Education

The majority of nurses today are looking to attain higher education when starting their nursing careers. With 45.4% earning an Associate Degree in nursing, 34.2% completing a BA and 20.4%

achieving their education through in hospital diploma programs. Figure 8 represents a more recent



statistic in nursing education.

Figure 8; Nursing Education Level

Retrieved from <https://slideplayer.com/slide/10668266/>

Conclusion

Insert Text Here

User Behaviour

Method

A literature search was used to find meaningful information that pertained to the behaviour of bedside nurses. This search was completed using resources such as Google and the Humber Library.

The search terms used were the following:

- “Nurse Fitness Level”
- “Common Ailments of Nursing”
- “Mental Health of Nurses”
- “Nurse Lifestyle”

Findings

Activity Level

According to a study conducted in regards to nurse health behaviour, found that 50% of Registered Nurses participate in the recommended daily amount of physical activity. This has led to 30% - 53% of the nursing population being overweight, similar to that of the American national average (Bevans 2017).

Common Health Detriments

_____ A simple search has led to massive findings. Nurses have been forgotten about in today's healthcare system as many suffer from a variety of health issues. The most common being cardiovascular disease and gastrointestinal disease caused by changing shift work. It is also important to note that the job description is extremely physically demanding, and has led many to physical fatigue and overall exhaustion.

Mental Health

_____ The detriments to the wellbeing of nurses caused by this line of work goes beyond just the physical, as it also affects the mental. Due to sleep deprivation and other external factors as a result of the job description, many suffer from anxiety and depression. In fact 36.4% of nurses have tested positive for Depression as well as 26.1% are positive for anxiety (Canadian Federation of Nurse Unions 2020). Unfortunately the troubling statistics do not stop there, as 1 in 3 nurses have admitted to contemplating suicide (Canadian Federation of Nurse Unions 2020).

Lifestyle

_____ While nurses can be seen as healthy, some of their behaviours can state otherwise. With weekly shift changes, and long hour stretches, getting proper sleep is seemingly impossible, leading to sleep deprivation. Studies have also proven that 62% of nurses choose to eat out (junk food) a minimum of 2 times a week (Bevans 2017). Sleep and eating are not the only areas of life nursing adversely affects. The social lives of these practitioners also suffer as many of them are unable to maintain a proper

work-life balance, missing gathering and holidays due to rotating schedules (Eastern Illinois University 2019).

Conclusion

The variable found within this study seems to be none other than the individual. With location only changing the level of income being earned, the remaining factors affecting behaviour of the user seem to be internal than anything else. With the individual being able to determine what they let affect them.

User Profile Summary

User	Description
Primary	Bedside Nurses
Secondary	Nurse Educators
Tertiary	Patients

Primary User Profile

Demographics

Age: Early 20s - Late 50s

Gender: Predominantly Female (91%)

Ethnicity: Cocasian (81%)

Education: University Level Degree

Income: 40\$-90\$ Thousand

Behaviours

Activity Level: Under 60min of Physical Activity

Health Detriments: Moderate

Mental Health: Moderate - High Susceptibility

Lifestyle: Anti-social and Unhealthy

Persona



Name: Jennifer Carter

Age: 32

Occupation: ICU Nurse

Income: \$68 000/year

Education: Bachelor in

Relationship Status: Married w/ 3 Kids

Location: Calgary, Alberta

Years of Experience: 5 Years

Social: Works with 14 other Nurses, however sticks to oneself outside of work

Activity Level: Constant walking at work, Moderate activity outside of work

Hobbies: Baking, Hiking, Watching TV Game Shows

Profile

Jennifer Carter is a caucasian female working in the ICU unit. She has attended Ryerson University where she earned her Bachelors in Science of Nursing and later moved to Calgary, Alberta where she found a better opportunity for furthering her career. Jennifer has also earned a diploma in Marketing but chose to leave that life behind at the age of 23, to pursue a career in nursing. She has now accumulated 5 years of experience working at Calgary Metro Hospital, where she was hired directly after graduating. Taking care of the ill and rehabilitating them to their former health is what she enjoys most about her job.

User Behavior

Jennifer is often on her feet as she strives to provide care to her given patient load. Being in the ICU situations constantly change at a moments notice, requiring her to be adaptive and quick thinking. She rarely has time to take a break and often solely interacts with the doctor on call. External interaction with specialists and other nurses have led to friendships that are confined within the work environment. Although this work is tiring, Jennifer finds it rewards and she cares for the health of her community.

Jennifer and New Technology

Jennifer has been in contact with healthcare equipment ever since her days in practicum as a university student. Since then she has grown accustomed to the way things operate, however is willing to learn as she understands that the healthcare industry is ever changing. While she is welcome to change, she is troubled by how easily some new technology can be implemented into her daily routine of providing care to her patients. As the hospital pays for all incoming new tech, Jennifer does not have to pay for

anything, including training of how to use this new equipment.

Product Research

Benchmarking

Product #1

Dr.Scholl's Insoles

<https://www.drscholls.com/pc/massaging-gel-technology/>

Promotional Piece *(Highlight the Benefit)*

Massaging Gel® technology. Massaging Gel® technology has **Responsive-Wave Cushioning™** with multi-layer gel waves.

We designed **Dr. Scholl's® Comfort & Energy Work Insoles** especially for people who work on their feet all day and experience discomfort and fatigue in their feet and legs.

Product Benefits

- **Superior shock** absorption helps you stay more energized while you work
- **Rugged construction** designed for demanding environments such as hard or uneven surfaces
- Helps **reduce muscle fatigue** in feet and legs so you can stay on your feet longer
- With **reinforced arch support**: firm columns provide **contoured support** to overworked arch area

Features *(Highlight the Features)*

Dr.Scholl's 4 Point Message Gel Insert Breakdown



1. **Responsive-Wave Cushioning™** **Massaging Gel®** Advanced multi-layer waves in the heel and arch provide **all-day shock absorption** and **cushioning** where you need it most
2. **Reinforced arch support** Reinforced construction and side support help **support arch** as you move through your stride
3. **Cooling vents** Keep **feet cool** and **dry** on the job
4. **Extra forefoot cushioning** to **protect** the sensitive **ball of foot**

Product #2

Nike Aeroadapt Compression

<http://www.norco.com/bikes/urban/urban-lifestyle/heart/>

Promotional Piece *(Highlight the Benefit)*

The Nike Pro AeroAdapt Tights have **breathable fabric** in high-heat areas to help **keep you cool** and **comfortable** during your most intense workouts.

A **compressive design** offers **lasting support**. This product is made from at least **50% recycled polyester**.

Features *(Highlight the Features)*

Nike Pro AeroAdapt Tights Tech Pack



1. **Adaptable Ventilation** - Nike AeroAdapt technology uses targeted panels of sweat-activated vents to help **keep you at the optimal temperature**.
2. **Sweat-Wicking Power** - Dri-FIT Technology **moves sweat** from your skin to help you **stay dry and comfortable**.
3. **Supportive Feel** - Compressive fabric hugs your body for **distraction-free support**. The elastic waistband helps **keep the tights in place** while you train or compete.

Product #3**Shock Doctor Knee Support w/ Dual Hinges**

<https://www.unitedsportsbrands.ca/collections/braces-supports/products/shock-knee-support-with-dual-hinges>

Promotional Piece *(Highlight the Benefit)*

Medial and lateral hinges ensure **mobility and performance** in the Knee Support with Dual Hinges. A **conically shaped upper strap wrap** provides **compression** and the **X-Fit® lower strap** securely wraps the leg and overlaps the hinge for **enhanced stability** during flex.

An **anatomical pre-curved design** yields **premier fit** and **stability**, and **N-Text™** air-flow keeps the **knee cool** and **dry** while promoting **therapeutic warmth**.

Features *(Highlight the Features)***Shock Doctors Features Breakdown**

1. **Quick-wrap upper strap** with integrated **elastic full-wrap support**
2. **X-Fit® lower strap** securely wraps lower leg, overlapping hinge to **maximize stability**
3. **Medial/lateral stability dual hinges** with **hyperextension stops**
4. **Aluminum stability stays** **securely positioned** in **integrated sleeves**
5. **Anatomical** precurved **enhanced-fit** design
6. **Four-way stretch spandex** [elastane] mesh at back of knee for **comfortable flex and ventilation**
7. **Premium stitching** assembly, **patella support** finishing and spandex [elastane] binding for **long lasting comfort**
8. **Convenient finger tabs** offer **easy grip pull** when fitting
9. **N-Text™** airflow vented **moisture-wicking** neoprene

Product #4**ThermaCare HeatWraps**

<https://www.thermacare.com/heat-wraps>

Promotional Piece *(Highlight the Benefit)*

From hot baths to heating pads, heat therapy is widely known to help ease muscle pain, reduce soreness, and loosen tight muscles. ThermaCare® HeatWraps use patented technology that **produces real heat** to help your body **rebuild damaged tissue** and **accelerate healing**.

Not only are ThermaCare® HeatWraps **drug-free**, but they're also **discreet and portable**, so you can use them when you're relaxing at home or on the go.

ThermaCare Packaging Breakdown

1. **16 hours of pain relief**. That's up to **8 hours of heat** while you wear it, plus **8 hours of relief** after you take it off.
2. **Enhanced elasticity** for a **better fit** and **more targeted relief**.
3. Designed **specifically to fit** your lower back and hip area.
4. **Delivers heat deep** into tissue to **relax, soothe, and unlock tight muscles**.
5. **Patented heat cells** get right to the source, to **relieve pain and accelerate healing**.
6. **Allows you to move freely** while it **delivers therapeutic heat**.
7. **Thin enough to wear discreetly** under clothing.
8. **Flexible enough to be worn on the go** or while relaxing

Key Benefits of Comparable Products	
<i>Keyword</i>	<i>Frequency</i>
Comfort	26
Style	5
Support	10
Relief	9

Key Features of Comparable Products	
<i>Keyword</i>	<i>Frequency</i>
Material	14
Adjustability	12
Relief	9

Analysis

Needs Statement

Needs Analysis

Wishes/Wants:

- Integrated intelligent materials (Heating, Cooling, Breathable, etc.)
- High Adjustability that is adaptive to changing body shapes
- Reduced fatigue during extended wear

Immediate Needs:

- Automated Relief (Requiring lack of user input)
- Cognitive Feedback (Analytical Data of Mental Health)
- Full Body Relief
- Wholistic Approach to Therapy (Relief and Prevention)

Latent Needs:

- Styling
- Convenient to use
- Ease of Maintenance (Reduce need to be Laundered)

CAD Development

I.C.A. Intelligent Compression Apparatus

Adaptive Air Compression

Reactionary compression system to mitigate any discomfort or pain felt by the wearer.

Top and Bottom Undergarment

15-20mmHg compression rating to increase blood circulation and lower swelling in limbs.

Fatigue Monitoring

Electrodes pickup on muscle fatigue and pain transmitting the information to the adaptive compression for a reactionary system

Connectivity

Bluetooth and Wifi connectivity to allow wearer to customize inflation and track muscular fatigue.



How it Works



Inflatable Components

Plastic inserts embedded in the neoprene fabric coupled with air injecting motor allow for inflation in desired areas of the body.



Muscle Fatigue Monitoring

Strategically placed electrodes combined with flexible battery packs allow for muscle weariness to be monitored, directing the adaptive compression based on the needs of the user.



Physical Model







Approval Forms

<p>IDSN 4002 SENIOR LEVEL THESIS ONE</p> <p>FTA-4 THESIS TOPIC APPROVAL (TEMPLATE) <small>This project/assignment constitutes 5% of total mark for the course</small></p>	<p>Humber ITAL / Faculty of Applied Sciences & Applied Technology Bachelor of Industrial Design / FALL 2020 Catherine Chong / Sandro Zaccolo</p> <p>Start: Week #4 / Sep-28 Due: Week #5 / Oct-05</p>
<p>THESIS TOPIC APPROVAL:</p>	
<p>Student Name:</p>	<p>Philip Orellana</p>
<p>Topic Title:</p>	<p>How may we improve the well-being of nurses who worked in high stress care system?</p>
<p>Abstract</p>	
<p>As funding within the health care system continues to decline, nurses working in hospitals continue to be outnumbered by the patients they receive, leading to high patient loads. These high patient loads result in a multitude of negative health effects for the practitioners working these bedside positions. Currently the health of nurses working in the hospital environments are being neglected. An increased amount of stress, fatigue and other detriments quickly add to the decline of the overall health of these nurses. The goal of this thesis proposal is to shift the way of thinking of the current health care system by not only focusing on the patients being treated but also taking into account the health of those providing care. This thesis suggests a complete analysis of daily tasks nurses are exposed to, using a variety of data collection methods such as interviews and surveys, in order to identify common challenges that can be addressed by means of product design. A full-size model will be constructed based on qualitative research in order analyze existing ergonomics and further develop the consideration of full body human interaction. A tangible design solution will be created to benefit the current work-lifestyle of bedside nurses facing high stress situations; further enhancing their overall health.</p>	
<p>Student Signature(s): <i>P.O</i></p>	<p>Instructor Signature(s): <i>Catherine Chong Sandro Zaccolo</i></p>
<p>Date: 04/10/2020</p>	<p>Date: 03 / 11 / 2020</p>
<p>Chong, Kappen, Thomson, Zaccolo</p>	

<p>IDSN 4502 SENIOR LEVEL THESIS TWO</p>	<p>Humber ITAL / Faculty of Applied Sciences & Technology Bachelor of Industrial Design / WINTER 2021 Catherine Chong / Sandro Zaccolo</p>
<p>CRITICAL MILESTONES: APPROVAL FOR CAD DEVELOPMENT & MODEL FABRICATION</p>	
<p>Student Name:</p>	<p>Philip Orellana</p>
<p>Topic / Thesis Title:</p>	<p>Adaptive Compression Suit</p>
<p>THESIS DESIGN APPROVAL FORM</p>	
<p>This design is approved to proceed for the following: <input checked="" type="checkbox"/> CAD Design and Development Phase</p>	
<p>Comment: Initial CAD progress reasonably as of week #12 / April 12th, continue with detailing and refinement. CAD must complete before model fabrication.</p>	
<p>This design is approved to proceed for the following: <input checked="" type="checkbox"/> Model Fabrication Including Rapid Prototyping and Model Building Phase</p>	
<p>Comment: Design development progress reasonably as of week #12 / April 12th, once CAD is completed, can move forward to model fabrication from week #12 onward.</p>	
<p>Instructor Signature(s):</p> <div style="font-family: cursive; font-size: 1.2em; color: blue;"> Catherine Chong Sandro Zaccolo </div>	
<p>Date:</p>	<p>12th April 2021</p>
<p>1 Chong, Kappen, Thomson, Zaccolo</p>	

