Development and Application of a Functional Apparel Framework Using Mixed Methods

by

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Abstract

This study employed a mixed method approach to develop and apply the proposed Multidimension Functional Apparel Framework (MFAF) to two separate case studies. The proposed functional apparel framework was developed from an extensive literature review of over 180 articles, books, and proceedings. The MFAF is divided into four dimensions; (a) end-user, (b) task, (c) design, and (d) production, and has twenty-eight (28) variables. Case study 1 investigated the usage and expectations of sun protective apparel for children. The second case study investigated wildland firefighters' perceptions of their NFPA 1977 Protective Clothing along with any perceived functionality differences between NFPA 1977 apparel editions. The qualitative and quantitative findings were analyzed separately for both studies and two additional variables were found to be necessary in the framework. A modified Multidimensional Functional Apparel Framework with all 30 variables was proposed for use by future functional apparel researchers.

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CHAPTER 1: INTRODUCTION

Background

Artifacts of cloth and fur discovered by archeologists document the use of functional apparel worn by humans to explore the extreme Arctic environment during the early 17th century (Dumond et al., 2018). Prior to the 20th century, there was little to no documentation of the types of functional apparel worn or if there were functional apparel problems experienced by humans. It was during the Heroic Age of Antarctic Exploration (1897 -1922) that various explorations began documenting functional apparel and equipment employed in journals, memoirs, and through photography (Cherry-Garrard, 1922; Fitzsimons, 2012; Scott, 2001). A famous British Royal Navy officer and explorer, Captain Robert Falcon Scott, was one of the first to list the quantities of wool and fur clothing and equipment used, along with details of how it was worn and its effectiveness during his first Antarctic expedition in 1901 (Scott, 2001). Cherry-Garrard (1922) reported in his book, *The Worst Journey in the World, 1911-1913*, the inadequacies of their apparel to keep them protected and comfortable in the Antarctic, especially when it came to moisture retention, insulation, fit, and mobility. Cherry-Garrard (1922) stated that the natural fiber apparel brought for the exploration was not as effective as the fur apparel in keeping them protected in the freezing conditions. Explorers commonly experienced frostbite, hypothermia, and frozen apparel during this period and experimented with wearing different functional apparel (Cherry-Garrard, 1922; Fitzsimons, 2012; Scott, 2001). By the end of the Heroic Age of Antarctic Exploration, an established layering system had been developed to help future explorers protect their bodies and function in the harsh conditions (Ward, 2001).

World War II brought advances to the area of functional apparel research amidst reported discernible inadequacies in soldier uniforms (Doriot, 1944; Kennedy, 1945). Kennedy's (1945) research chronicled the inadequacies of wool military uniforms for wind and water resistance, low abrasion resistance, and shrinkage problems. These inadequacies could lead to lower body temperatures due to poor insulating properties when wet or during high winds, shorter life expectancy of uniforms, laundering difficulties, and military personnel being less effective when executing their duties due to discomfort (Kennedy, 1945). Kennedy (1945) suggested future research and testing into fiber finishes, synthetic fibers or fiber blends, along with improved seam construction for better military uniforms.

By the 1970's, functional apparel had advanced research not only for the military and occupations, but also for the elderly, handicapped individuals, and rehabilitating patients (Aswell, 1952; Clawson, 1942; Hawkins, 1962; Hays, Joiner, & Caudill, 1945; Newton, 1976; Rusk & Taylor, 1959; Schuste & Kelly, 1974; Vaughn & Jurczak, 1969; Warden & Dedmon, 1975). During the 1970's functional apparel progressed into academia with specific classes taught on the topic at Cornell University (Ashdown, 2003). The first model for designing functional apparel, Functional Clothing Design Process & Strategy Selection Model, was presented at the Association of College Professors of Textiles and Clothing meeting in 1979 (Orlando, 1979). By 1984, the first textbook, *Clothing: A Portable Environment,* was published to aid in the development of functional apparel (Watkins, 1984). This textbook covered many aspects of functional apparel design from task analysis to textiles, mobility, comfort, protection, and donning and doffing (Watkins, 1984). Today, there are multiple textbooks and journal articles on various functional apparel including textiles to end-user evaluations.

Problem Statement

A review of over 180 published journal articles, books, and proceedings on diverse types of functional apparel was undertaken for the purpose of this dissertation research that revealed fifteen different models or frameworks for functional apparel (see Table 1 and Appendix A).

These models or frameworks used in functional apparel research varied in purpose from those looking specifically at clothing comfort dimensions, the clothing design process, or clothing product development (Branson & Sweeney, 1991; Dejonge, 1984; Rosenblad-William, 1985). Some models were applicable for multiple industries (i.e., universal design and user-centered design) such as ergonomics, sports, disabilities, or industrial heath (Braganca et al., 2018; Holmér, 2006; Kabel, McBee-Black, & Dimka, 2016; Lamb & Kallal, 1992; Naesgaard, Storholmen, Wiggen, & Reitan, 2017; Shanley, Slaten, & Shanley, 1993; Thoren, 1996). Others were designed as a teaching model, specific for a functional apparel attribute (i.e., comfort or protection), or were for a specific industry (Chae, 2017; Lamb & Kallal, 1992; Shanley et al., 1993). Overall usage was for occupational (31.6%), everyday apparel (29.9%), sports (25.1%), medical (11.2%) or were a review of functional apparel (2.1%) (see Table 1). The majority of the studies on functional apparel did not use a framework or model. Lamb & Kallal's (1992) Functional, Expressive, and Aesthetic model was used the most frequently (9.6%) when a framework was used in the study, but there was no framework or model consistently used for functional apparel studies (see Table 1). Variables researched for functional apparel were diverse and comfort was used the most (8.5%), followed by textiles (7.2%), protection (6.5%), and aesthetic influences (6.4%) (see Table 1).

Table 1

Summary of literature review by usage, framework, and variables by dimension (N = 187)

Functional apparel usage	Quantity	%
Occupational	59	31.6%
Everyday	56	29.9%
Sports	47	25.1%
Medical	21	11.2%
Review	4	2.1%

Table 1 Continued

Framework used	Quantity	%
None reported	136	72.7%
Functional, Expressive, and Aesthetic Design	18	9.6%
Design Process Model	9	4.8%
Various theories on clothing	7	3.7%
Universal Design	3	1.6%
User-Centered Design	2	1.1%
User-Oriented Product Design	2	1.1%
Clothing Comfort Model	1	0.5%
Clothing Purchase Decision-Making Factors	1	0.5%
Comfort Dimensions	1	0.5%
Design of wearables	1	0.5%
Engineering anthropometry methods	1	0.5%
Inclusive Design	1	0.5%
Objectifying Apparel Design	1	0.5%
Product Design Process	1	0.5%
Quality Function Deployment	1	0.5%
Soft Systems Methodology	1	0.5%

Variable by dimension	Quantity	%
End-user		
Identity	76	4.4%
Aesthetic Influences	111	6.4%
Social or Ethical Concerns	12	0.7%
Affordability	55	3.2%
Brand	22	1.3%
Task		
Environmental Considerations	96	5.5%
Task Analysis	56	3.2%
Protection	113	6.5%
Regulations	32	1.8%
Compliance	7	0.4%
Equipment Interactions	54	3.1%
Textiles	125	7.2%
Adaptive	34	2.0%
Wearable Technology	34	2.0%
Design		
Fit	106	6.1%
Body Shape	26	1.5%
Mobility	108	6.2%
Sensory	20	1.1%
Durability	45	2.6%
Comfort	147	8.4%
Performance	71	4.1%

Table 1 Continued

Variable by dimension	Quantity	%
Design continued		
Components & Closures	104	6.0%
Donning and Doffing	81	4.6%
Production		
Sizing System	56	3.2%
Construction	60	3.4%
Quality	30	1.7%
Ease of Care	50	2.9%
Availability	12	0.7%

Researchers reported various aspects that should be considered with functional apparel, but that are not currently in a particular model or framework; some aspects mentioned include environment, affordability, brand, sizing, apparel components, and equipment interactions (Ahsan & Tullio-Pow, 2015; Bergen, Capjack, McConnan, & Richards, 1996; Boorady, 2011; Braganca et al., 2018; Chae & Schofield-Tomschin, 2010; Cho, 2006; Emerich, 2011; Faust & Carrier, 2014; May-Plumlee & Pittman, 2002; Michaelson, Teel, & Chattaraman, 2018; Morris, Park, & Sarkar, 2017; Stokes & Black, 2012; Thompson, 2017). Environmental considerations were mentioned with natural disaster survivors apparel, motorcyclists, sailors, butchers, and medical apparel (Ahsan & Tullio-Pow, 2015; Bye & Hakala, 2005; Ilmarinen, E., & Korhonen, 1990; Kwok, Li, Fan, & Wai, 1999; Thompson, 2017; Varnsverry, 2005). Affordability was a consideration in recreational sports, medical, and occupational apparel (Bergen et al., 1996; Bye & Hakala, 2005; Goncu-Berk & Topcuoglu, 2017; Huck & Kim, 1997; Michaelson, Kim, & Ha, 2018; Michaelson, Teel, et al., 2018; Mitchka, Black, Heitmeyer, & Cloud, 2009). The main research gap that emerged from this review was the lack of an adequate framework to investigate, evaluate, or design for multidimensional aspects (end-user, task, design, and production) and types of functional apparel.

Existing Frameworks

The review of over 180 functional apparel articles, books, and proceedings found almost two dozen frameworks employed (see Appendix A). The most commonly reported framework employed (18 times or 10%) was Lamb & Kallal's (1992) Functional, Expressive, and Aesthetic (FEA) consumer needs framework (see Appendix A.1). This framework was originally developed to teach apparel design students about consumer needs; hence, it was not developed exclusively for functional apparel design (Lamb & Kallal, 1992). The FEA framework was designed for the problem identification phase and the evaluation phase of apparel needs. The FEA framework begins with the target consumer, then the culture that surrounds that target consumer; followed by functional, expressive, and aesthetic categories. The functional Dimension evaluates fit, mobility, comfort, protection, and donning and doffing. The expressive Dimension includes values, roles, status, and self-esteem. Lastly, the aesthetic Dimension is comprised of art elements, design principles, and the body and garment relationship. Functional apparel researchers have used this framework by applying all three FEA categories or with only one or two of the FEA categories (Hall & Orzada, 2013; Hwang, Chung, & Sanders, 2016; Jin & Black, 2012; Michaelson, Kim, et al., 2018; Stokes & Black, 2012; Thompson & Anyakoha, 2012). The researchers for these 18 studies used the FEA model to investigate occupational, sport, medical, and every day functional apparel. In addition to the FEA variables, these studies also employed functional apparel variables outside the FEA framework: environmental considerations, components and closures, affordability, care, brand, task analysis, regulations, durability, sizing, construction, availability, and wearable technology. This inclusion of additional variables indicates the need to broaden the functional apparel framework beyond the FEA model.

DeJonge's (1984) functional clothing design process and strategy selection model, featured in the forward of *Clothing: The Portable Environment* by Watkins (1984), was utilized in eight research studies of functional apparel (see Appendix A.2). It should be noted that some past researchers referenced DeJonge (1984) while others referenced Watkins' 1985 subsequent edition of *Clothing: The Portable Environment*. However, all eight of these research studies referenced the same design process model. The functional clothing design process and strategy selection model was adapted from Jones (1970) fashion design process to provide a step-by-step process for evaluating existing functional apparel in the market (Watkins, 1984). This model was developed as a means of teaching functional clothing design in the classroom as a 6-step process.

The model starts with a request to investigate a specific need of the consumer. Next, the design situation is explored by observing the consumer in the garment doing tasks, conducting market research, literature review, identifying crucial design variables, and defining the garment problem. The third step assesses the garment problem perceived by the consumer by observing activity, movement, impact, thermal, and social-psychological factors. The fourth step charts and prioritizes the specifications by revisiting the primary purpose of the garment along with crucial design variables. The fifth step is establishing the design criteria based on step 4, along with testing materials, evaluating solutions creatively, and assessing if it can meet the initial request made by step 1. The final step prototypes a garment based on the step-by-step process to see if the consumer is satisfied with the garment solution proposed. Watkins' (1984) textbook proceeds to identify crucial design criteria for functional apparel, such as, body responses to environment, materials, thermal protection, impact theory and protective materials, mobility, fasteners, and increasing body performance.

DeJonge's (1984) model was used in six research studies that involved occupational apparel assessments (Black & Cloud, 2008; Chan et al., 2015; Huck & Kim, 1997; McQuerry, Barker, & DenHartog, 2018), medical apparel (Bergen et al., 1996) and sport apparel (Mitchka et al., 2009). All but two of these studies used the entire 6-step process to the prototype stage (Bergen et al., 1996; Chan et al., 2015; Huck & Kim, 1997; McQuerry et al., 2018). Used in conjunction the model and textbook are good tools specifically for functional apparel assessment or evaluation. The review found eight additional functional apparel variables employed in these studies that were not accounted for by DeJonge's (1984) model: aesthetics, care, affordability, quality, brand, regulations, body shape, and sizing. It should also be noted that the Functional Clothing Design, an updated textbook based on Clothing: The Portable Environment, published in 2015, incorporated a new chapter on smart clothing and wearable technology. The six studies reviewed did not incorporate any technology. However, other researchers of occupational, medical, sport, and everyday functional apparel, accounting for 33 studies (see Appendix B), did report its necessity in functional apparel design (Bechtold, Caven, & Wright, 2015; Biswas, Infirri, Hagman, & Berglin, 2018; Goncu-Berk & Topcuoglu, 2017; Hwang et al., 2016; Kabel et al., 2016; Katsis, Goletsis, Rigas, & Fotiadis, 2011).

Three of the other frameworks, universal design, user-centered design, and user-oriented product development, consider the user of the apparel (Connell et al., 1997; Norman & Draper, 1986; Rosenblad-William, 1985). These frameworks were not originally designed for apparel but were adapted for functional apparel design. Ronald L. Mace, architect (1941-1998), has been credited for the concept of universal design (Saxon, 1998). Universal design has seven principles (see Appendix A.3) to aid designers of environments, products, and communications so that the design is universally usable (Connell et al., 1997). Many designers have used these principles in architectural, interior, or product design for individuals with a disability (Connell et al., 1997; Park, 2014). The seven principles guide the designers in (a) equitable use, (b) flexible use, (c) simple and intuitive use, (d) perceptible information, (e) tolerance for error, (f) lower physical effort, along with (g) size and space for approach and use for the user. The review found that this framework was used for everyday and medical apparel (Carroll & Kincade, 2007; Kabel et al., 2016; Park, 2014; Tullio-Pow, Schaefer, Zhu, Kolenchenko, & Nyhof-Young, 2011). Connell et al. (1997) specified that Universal Design may have additional variables such as, aesthetics, cost, safety, gender, and culture, that should be considered when designing. Also, additional functional apparel variables, such as wearable technology, sizing, availability, and quality, were not addressed in the Universal Design framework (Carroll & Kincade, 2007; Kabel et al., 2016; Park, 2014).

User-centered design (UCD) is a framework of four phases to aid the designer in analyzing the way a user would most efficiently use the product (Norman & Draper, 1986). The UCD framework was originally developed for human-computer interaction in software development but has since been used as a framework for designing functional apparel (Han, Shin, & Chow, 2015; Morris et al., 2017; Naesgaard et al., 2017). This framework became the foundation for International Standard 9241-210:2010 "Ergonomics of human-system interaction – Part 210: Human-centered design for interactive systems" that is used by U.S. Department of Health & Human Services for product design and development (International Organization for Standardization, 2010; U.S. Department of Health & Human Sciences, n.a.). The UCD framework focuses on the needs of the user and considers other variables, such as aesthetics, as secondary. The main phases of the UCD process are (a) specify the context of use, (b) specify the requirements, (c) produce product design solutions, and (d) evaluate designs (see Appendix

A.4) (U.S. Department of Health & Human Sciences, n.a.). The UCD is a broad framework with no specific set of variables for the researcher to use; the process aids in the design and development lifecycle while developing a deep understanding of the product user. Even though it has been used for medical, occupational, and sport apparel, it does not guide the future researcher with a set of variables common to functional apparel (Han et al., 2015; Morris et al., 2017; Naesgaard et al., 2017).

The user-oriented product development (UPD) method was applied to functional clothing design by Rosenblad-William (1985) and involves the user needs as the starting point. Rosenblad-William (1985) summarized the UPD method in nine steps: (a) identification of problem area, (b) problem analysis, (c) formulation of objective and project, (d) formulation of the demands of the user based on user studies, interviews, measurements, and other investigations, (e) data processing and analysis, (f) specification of the use-demands and transformation of these into technical terms, (g) development of ideas and technical solutions, (h) evaluation, modification and selection of prototype, and (i) evaluation of the final solution in relation to the objectives. The UPD method has been applied to three everyday functional apparel studies involving special needs apparel (Thoren, 1996; Tullio-Pow et al., 2011; Wang, Wu, Zhao, & Li, 2014). This method does not set out a specific set of variables for future researchers to use but, rather, a method or process to follow.

Last, the review of functional apparel research revealed several other frameworks, models, and theories beyond those mentioned above. These frameworks focused specifically on one functional apparel dimension, one dimension of apparel, or a theory. One functional apparel dimension, comfort, was developed by Branson and Sweeney's (1991) clothing comfort model that has been employed in occupational apparel research for ballistic vests (Barker & Black, 2009). Sontag's (1986) research developed specific comfort dimensions that were used for everyday insulating apparel. Although the dimension of comfort is important for specific end users, it would not be sufficient in designing all categories of functional apparel. For example, a framework developed and applied for the design of smart gloves exemplifies a specific approach (Goncu-Berk & Topcuoglu, 2017). An apparel design process developed by Orlando (1979) was used to develop and evaluate flight suits (Tan, Crown, & Capjack, 1998).

Additionally, theories from sociology and psychology have been incorporated into functional apparel research to help investigate the end-user's psycho-social needs. Symbolic use theory was used for cyclists, individuals with disabilities, and dementia related apparel needs (Casselman-Dickson & Damhorst, 1993; Freeman, Kaiser, & Wingate, 1985; Mahoney, LaRose, & Mahoney, 2015). Theories such as identity, self-efficacy, and reasoned action, have been used for functional apparel research as well (Chang, Hodges, & Yurchisin, 2013; Hendley & Bielby, 2012; Perkins, Crown, Rigakis, & Eggertson, 1992). Despite the value of these specific theories and their applications, a comprehensive framework listing the multidimensional aspects or variables needed for functional apparel research is missing in the current literature.

Objective of Study

The objective of this dissertation research is to create and apply a comprehensive multidimensional functional apparel framework for development, assessment, or investigation of diverse functional apparel categories. Development of the proposed framework is based on reviewing a large body of functional apparel research to assess variables needed in the proposed framework. Application of the proposed framework is based on conducting two separate research projects that evaluate if all necessary variables have been included in the proposed multidimensional framework or if additional variables need to be incorporated. The two research projects cover different demographics in age, gender, and occupation so that the suitability of the developed framework for use across multiple apparel categories and end uses of functional apparel can be explored.

This study will employ a mixed method approach to develop and apply the proposed multidimensional functional apparel framework. A convergent parallel mixed methods design will be used, which is a research design that simultaneously collects qualitative and quantitative data in parallel that is analyzed separately and then merged in the results (Creswell, 2014; Creswell & Plano Clark, 2018). In this study, reliable quantitative measures will be used to survey end-users of various functional apparel dimensions. The qualitative data gathered will be in the form of open-ended questions to investigate end-users' perceptions of various functional apparel. The reason for collecting both quantitative and qualitative data is to compare the two forms of data and ensure all variables have been integrated into the multidimensional framework that may not be revealed through employing a single method of data elicitation.

Significance of Study

Given the diverse research areas of functional apparel and the existence of multiple models, frameworks, and theories found in the literature for functional apparel, it is advantageous to have one comprehensive framework usable for any industry or area of functional apparel research. This study will identify all variables necessary to conduct diverse types of functional apparel research. Not all of this study's framework variables would be necessary for each future research project. The intent of the multidimensional framework is to help future researchers navigate through all levels and sub-levels of the framework. Future researchers should evaluate and identify which variables are needed for their specific functional apparel research study. The development of this model will allow future researchers to employ one comprehensive framework for designing, developing, and evaluating functional apparel.

Overview of Developed Multidimensional Functional Apparel Framework

A review of over 180 journal articles, books, and proceedings on diverse types of functional apparel, textiles, performance aspects, and manufacturing practices revealed 28 key variables from diverse research areas, such as textiles, apparel, medicine, ergonomics, and individual industries. The literature search was limited to English language materials only to avoid misinterpretation of translated results. These twenty-eight variables were then incorporated into the proposed Multidimensional Functional Apparel Framework (see Figure 1). The proposed multidimensional functional apparel framework is divided into four dimensions; (a) end-user, (b) task, (c) design, and (d) production. While most of these variables could be expanded further, each variable is summarized based on the literature found specifically on functional apparel.

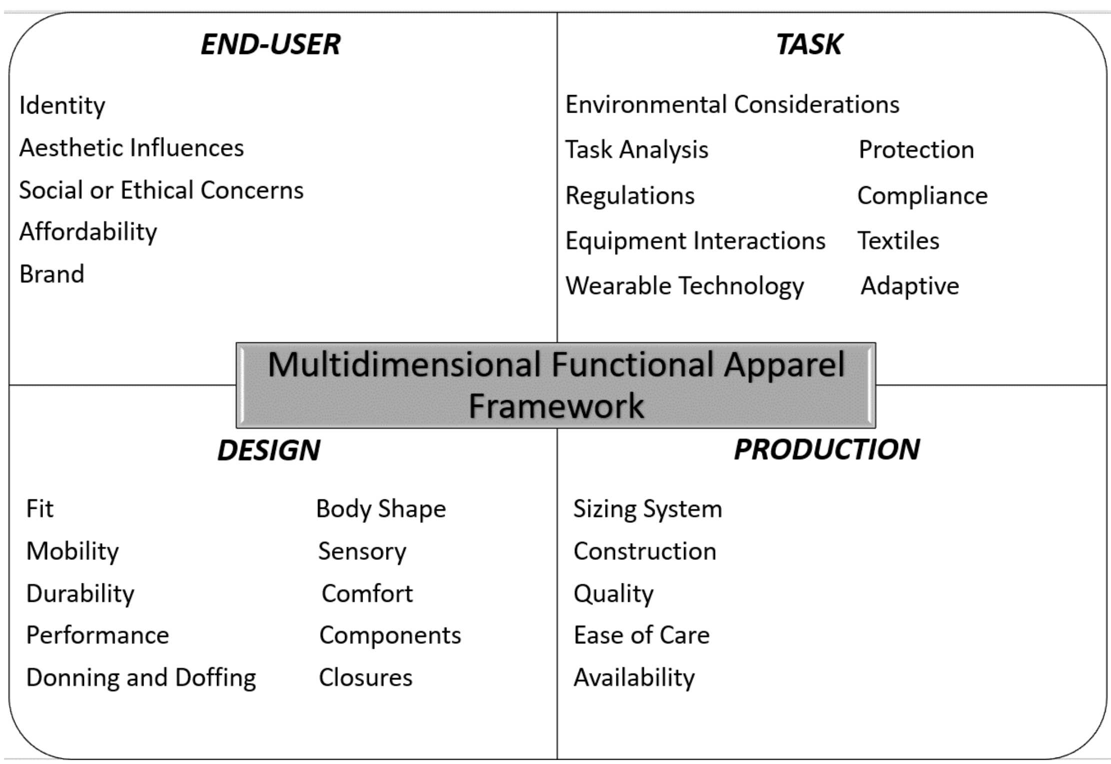


Figure 1. Proposed multidimensional functional apparel framework

Dimension 1: End-User

The end-user dimension contains five variables representing subjective socio-psychological, aesthetic, values-oriented characteristics about the end-user: (a) identity, (b) aesthetic influences, (c) social and ethical concerns, (d) affordability, and (e) brand. An end-user's identity while wearing apparel can help them integrate into society, group athletics, occupations, age groups, genders, cultural, ethnic, and religious roles, and even help reduce social stigma (Stets & Serpe, 2016). Apparel aesthetics are subjective and impact the apparel selection process based on end-users' preferences and includes personal style, fashionability, and color (Sproles, 1979). End-users also have social and ethical concerns about apparel, such about sustainability, which can be influenced by society, personal ethics, or other reasons (Hayes & Venkatraman, 2016; Motlogelwa, 2018; Radhakrishnan, 2015). Affordability and brand preferences are also subjective to end-users, so these variables were included within this dimension (Carlson & Donavan, 2012; Dodds, Monroe, & Grewal, 1991; Phillips, McQuarrie, & Griffin, 2014; Wee & Ming, 2003). Affordability of apparel was found to have a positive and negative affect on other variables, such as quality, value, and purchase intention (Dodds et al., 1991). Brand can be identified as a company or a celebrity; therefore the image of the brand must be kept consistent for long term success as a brand image communicates both meaning and value to the end-user (Carlson & Donavan, 2012; Phillips et al., 2014; Wee & Ming, 2003).

Dimension 2: Task

Task dimension investigates how the end-user completes their task and how the apparel can aid them and includes nine relevant variables: (a) environmental considerations, (b) task analysis, (c) protection, (d) regulations, (e) compliance, (f) equipment interactions, (g) textiles, (h) adaptive, and (i) wearable technology. The environment is an important consideration as a task can take place outdoors or, indoors, as well as in water, air, or outer space (Watkins & Dunne, 2015). Understanding how the task is completed (i.e., task analysis) needs to be ensured so the end-user can be properly protected (Connell et al., 1997; Watkins & Dunne, 2015). Regulations and compliance by the end-user can impact the end-user's safety (Barker & Black, 2009). Equipment interactions can impact the end-user by interfering with the end-users apparel or task (Laing & Sleivert, 2002; Michaelson, Teel, et al., 2018). Textiles, adaptability of the apparel, along with integrated wearable technology is also a consideration for the end-user in the task dimension as these variables can impact the task (Watkins & Dunne, 2015).

Dimension 3: Design

The design dimension has nine variables that need to be considered during the design of functional apparel to positively impact individual end-users while performing their tasks: (a) fit, (b) body shape, (c) mobility, (d) sensory, (e) durability, (f) comfort, (g) performance, (h) donning and doffing, and (i) components and closures. Investigating these variables during the design process can improve the way the apparel functions for the end-user. Research has shown that many of the variables in the design dimension can impact each other along with the overall perception of fit for the end-user (Ashdown, 2011; Boorady, 2011; Hayes & Venkatraman, 2016; Laing & Sleivert, 2002).

Dimension 4: Production

The last dimension, production, includes five variables that need to be considered during the manufacturing process: (a) sizing, (b) construction, (c) quality, (d) ease of care, and (e) and availability. This dimension covers many of the production considerations that go into manufacturing functional apparel (Kunz & Glock, 2004). These variables in the production dimension can be of interest to designers and manufacturers of functional apparel.

Overview of Application of the Multidimensional Functional Apparel Framework

Application of the Multidimensional Functional Apparel Framework (MFAF) was conducted through two case studies. Each case study used different variables within the four dimensions of the MFAF.

Case Study 1 – Investigating Usage and Expectations of Sun Protective Apparel in Children

This case study applies the Multidimensional Functional Apparel Framework (MFAF) by investigating the usage and expectations of sun protective apparel for children. Approximately 80% of a person's total lifetime sun exposure occurs during childhood (Preston & Stern, 1992). Outdoor activities, such as swimming, put children at an increased risk for overexposure, the leading cause of skin cancers, but this is preventable with proper sun protection (Glanz & Mayer, 2005; Moehrle, 2008). Researchers report sun protective clothing is the most effective sun protection, yet 16% or less actually wear protective clothing and less than half of children properly wear sunscreen, resulting in overexposure. Therefore, this mixed-methods study applies the proposed Multidimensional Functional Apparel Framework (MFAF) to investigate the (1) end-user dimension of aesthetic influences on style preferences in sun protection apparel, and affordability, (2) task dimension on expectations of protection from sun, compliance, and textiles, (3) design dimension on expectations of fit, body shape, comfort, mobility, durability, donning and doffing ease, (4) production dimension on expectations of sizing system, quality, ease of care, construction, and availability of children sun protective apparel, along with perceived deterrents in the usage of child sun protection apparel (see Figure 2).

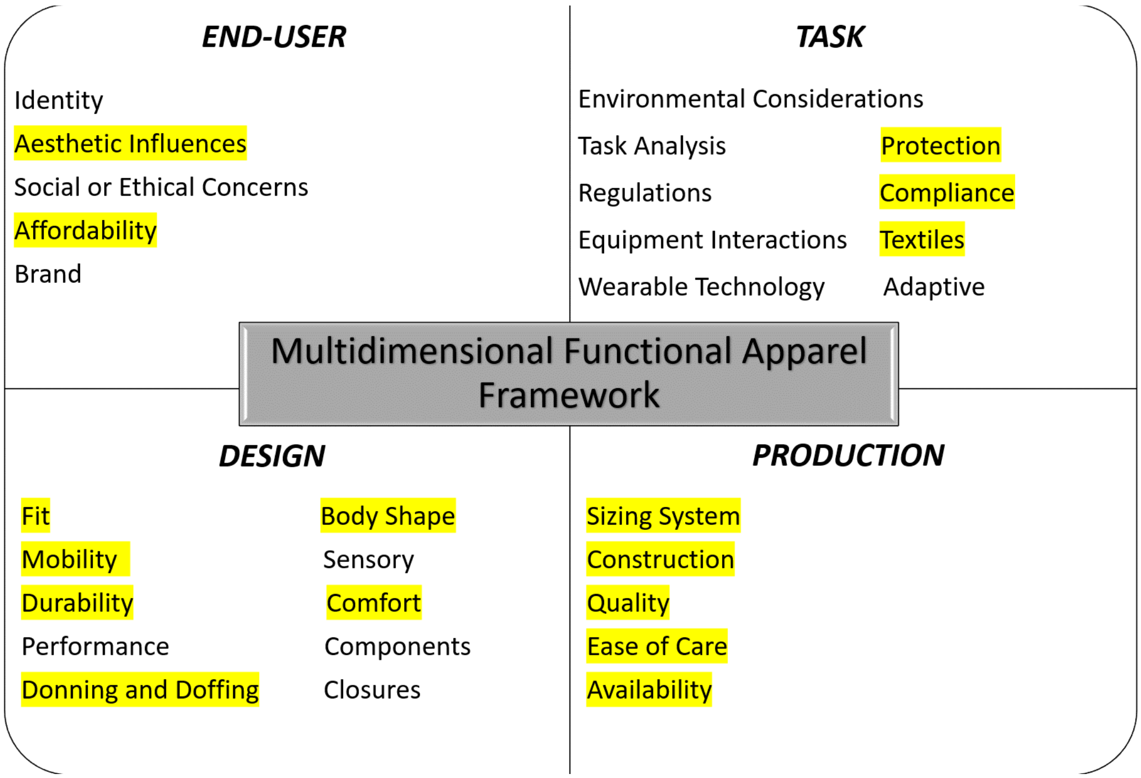


Figure 2. Application of Multidimensional Functional Apparel Framework to Case Study 1

Case Study 2 – Wildland Firefighters' Perceptions of NFPA 1977 Protective Apparel

This case study applies the proposed Multidimensional Functional Apparel Framework (MFAF) by investigating wildland firefighters' perceptions of their NFPA 1977 Protective Clothing along with any perceived functionality differences between NFPA 1977 edition 2005, 2011, and 2016 apparel. Wildland firefighter's apparel manufacturers must adhere to the current edition of NFPA 1977 "Standard on Protective Clothing and Equipment for Wildland Fire Fighting". NFPA 1977 has specific manufacturing requirements for wildland firefighters apparel sizing, performance of fabric, thread, fasteners, zippers, seams, laundering, labeling requirements and much more, yet there is limited to no literature investigating wildland firefighters' perceptions of their apparel. Edition changes to the NFPA 1977 may impact the overall functionality of apparel due to changes in sizing requirements, testing standards, or dimensional changes in the fabric due to home laundering. Wildland firefighters may own and wear different editions of NFPA 1977 protective apparel. Therefore, this study investigates wildland firefighters' a) perceptions of their NFPA 1977 Protective Clothing and b) perceived functionality differences between NFPA 1977 edition 2005, 2011, and 2016 apparel, using the Multidimensional Functional Apparel Framework (MFAF) (see Figure 3).

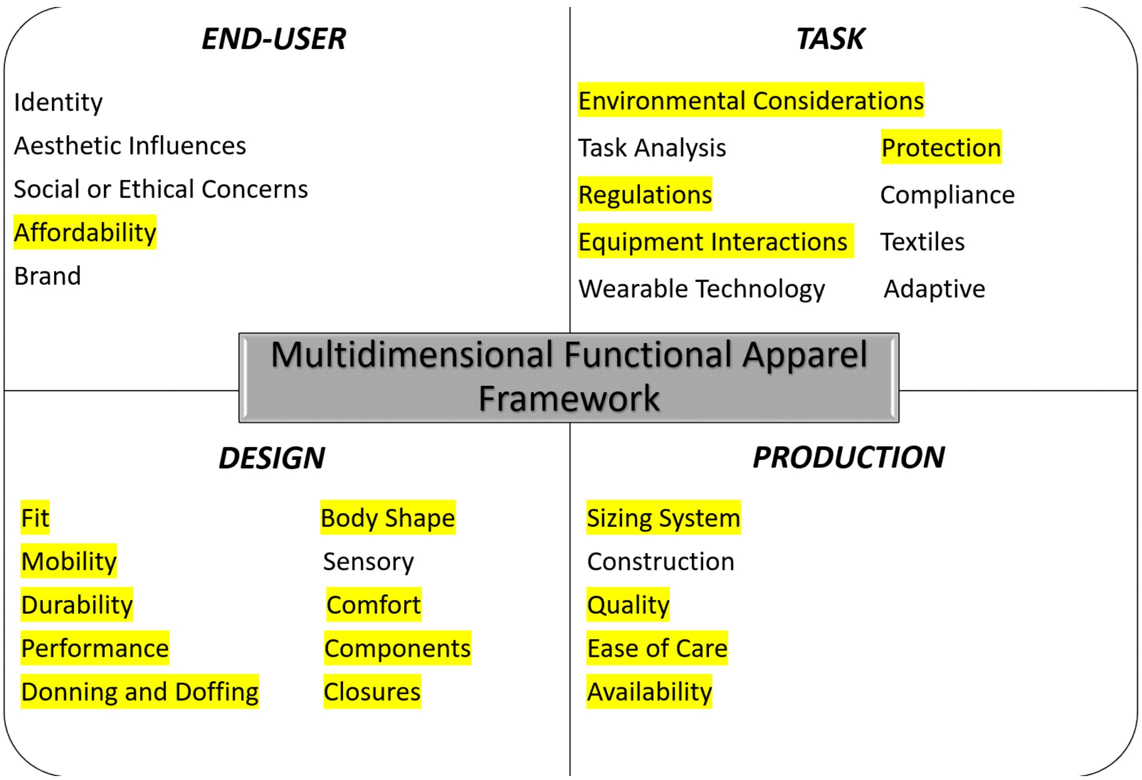


Figure 3. Application of Multidimensional Functional Apparel Framework in Case Study 2

Definition of Terms

- Adaptive: Ability to change the apparel style so the end-user or caregiver can more readily don and doff the apparel and aid in the physical, physiological, and psychological needs of the end-user (Kabel et al., 2016; Na, 2007; Watkins & Dunne, 2015).
- Aesthetics: An individual's perception of what is pleasing or beautiful (Jacobsen, Buchta, Köhler, & Schrager, 2004; Morganosky, 1987).

- Affordability: Affordability is perceived when the cost of a product is aligned with the end-user's perception of value based on their current income status (Kunz & Glock, 2004).
- Availability: The number of product items available for purchase by the end-user (Kunz & Glock, 2004).
- Brand: A specific name given to an organization that manufactures or produces apparel (Kunz & Glock, 2004).
- Body shape: A way to identify a person's figure based on their skeletal structure, tissues, muscle mass, and fat distribution, including height, weight, and fitness (Faust & Carrier, 2014).
- Care: The laundering of apparel with respect to washing, bleaching, ironing, and drying (Nayak & Padhye, 2015).
- Closures: A device used to open and close an area on the apparel (Huck & Bonhotal, 1997).
- Comfort: An individual's perception of comfortable apparel based on psychological, physiological, and physical aspects while in a specific environment (Branson & Sweeney, 1991; Das & Alagirusamy, 2010).
- Compliance: The ability of the end-user to conform with the regulations of a given apparel item (Barker & Black, 2009).
- Components: An item(s) that is a part of the finished apparel product (Kunz & Glock, 2004).
- Construction: Cutting fabric into pattern pieces which is then assembled into a garment by a sewing method (Dooley, 1930; Kunz & Glock, 2004).
- Disability: An impairment that can be recognized as physical or mental and limits an end-user in normal day to day activities (ADA National Network, 2019).

- Doff: An act of dressing whereby the apparel is removed from the body (Watkins & Dunne, 2015).
- Don: An act of dressing whereby the apparel is placed on the body (Watkins & Dunne, 2015).
- Durability: The apparel's ability to maintain its shape and construction without becoming worn, torn, ripped, or torn (Hunter, 2009).
- End-user: An end-user is a human, non-human, or object wearing functional apparel for a specific task (Watkins & Dunne, 2015).
- Environment: The specific surroundings in which the end-user performs a particular task that can be found in either an outdoor or indoor setting (Watkins & Dunne, 2015).
- Equipment interaction: Equipment interferes with end-user's ability to properly perform a function (Watkins & Dunne, 2015).
- Fit: An individual's subjective perception of how the apparel should lay, look, and move on the body (Boorady, 2011).
- Functional apparel: Apparel that performs a function for the end-user beyond a covering, such as providing thermal protection, impact protection, comfort, or performance enhancement (Gupta, 2011b; Watkins & Dunne, 2015).
- Identity theory: A theory developed by sociological psychologists whereby the role an individual occupies in the social structure is unique and shaped by numerous factors, such as demographics, personal characteristics, family, friends, age, gender, health, apparel, society, and cultural surroundings that can in turn impact their social interaction (Stets & Serpe, 2016).

- Mobility: The ability to perform movements freely and easily while wearing functional apparel (Gupta, 2011b; Watkins & Dunne, 2015).
- Performance: End-users' ability to effectively complete a task while in the functional apparel (Hayes & Venkatraman, 2016; Watkins & Dunne, 2015).
- Protection: The ability to cover the body so it keeps the end-user safe from a variety of harms (Gupta, 2011b; Watkins & Dunne, 2015).
- Quality: A perception by the end-user that the apparel has certain characteristics that are aligned with their valuation of the product (Kunz & Glock, 2004).
- Regulations: Sets of codes, standards, practices, or guidelines, which vary by government agencies, trade associations or organizations, that govern various aspects of apparel, such as textiles, sizing, seam strength, labeling, testing, and advertising (Fédération internationale de nation, 2016; National Fire Protection Association, 2016).
- Sensory: A physical sensation received from apparel that is received from the senses; such as touch, weight, sound, and sight. (Watkins & Dunne, 2015).
- Sizing: A way to communicate an individual's body measurements, like bust, waist, or hip, to a unit of measure, known as a size, designated by the apparel brand so it fits the individual (Ashdown, 2007).
- Smart apparel: Apparel that incorporates technology so it can monitor the end-users physical condition (Chan, Esteve, Fourniols, Escriba, & Campo, 2012; McCann & Bryson, 2009)
- Style: A set of garment characteristics that identify it as having a recognized name (Dooley, 1930).
- Task analysis: A means of observing an end-user to gain information about their specific task or activity (Watkins & Dunne, 2015).

- Wearable technology: A scientific advancement, such as a sensor, that is integrated into the apparel, so it can be used by the end-user while wearing it (McCann & Bryson, 2009).

CHAPTER 2: REVIEW OF LITERATURE

The literature review in this chapter is structured to apply the Multidimensional Functional Apparel Framework (MFAF) to the two case studies introduced in the previous chapter. This approach was taken since the two case studies have different functional apparel categories and focus on different end-users; hence, the literature review needs to be oriented towards the specific applications. Case study 1 investigates recreational functional apparel for children's swimwear; case study 2 explores wildland firefighters' perceptions of occupational functional apparel in the form of protective shirts and pants. For each case study, only the applied variables from the MFAF are discussed in the literature review and development of research questions.

Case Study 1 – Investigating Usage and Expectations of Sun Protective Apparel for Children

Purpose

The purpose of case study 1 was to apply the Multidimensional Functional Apparel Framework (MFAF) to investigate usage and expectations of sun protective apparel for children (see Figure 4). With respect to the end-user dimension, this case study investigated the parents' expectations for aesthetic influences on style, their perceptions of affordability and any perceived deterrents in the usage of sun protective apparel in children. For the task dimension, this case study investigated parents' expectations of sun protection in swimwear, compliance in usage of protective swimwear, and functions of the textiles used in swimwear. The design dimension of the MFAF was applied to investigate the parents' perceptions of children's swimwear fit, body shape, mobility, durability, comfort, and donning and doffing ease. Lastly, the production dimension was applied to investigate the parents' perceptions of children's swimwear sizing, construction, quality, ease of care, and availability.

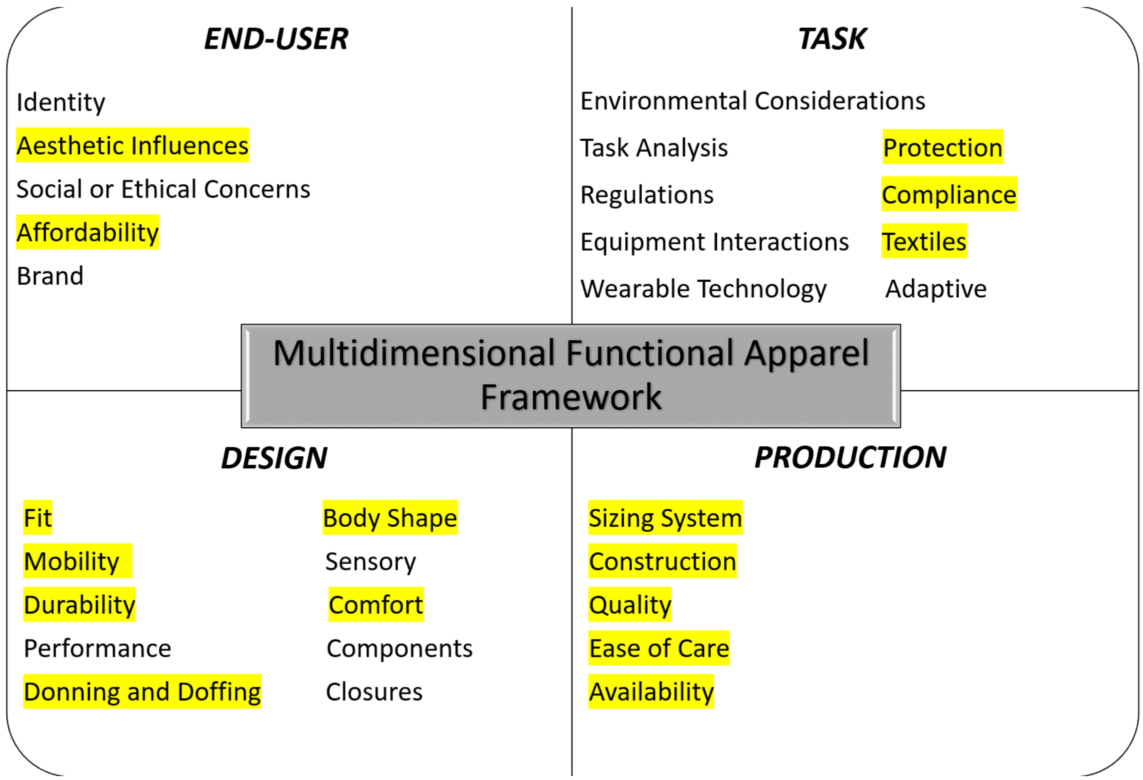


Figure 4. Application of Multidimensional Functional Apparel Framework to Case Study 1

End-User: Aesthetic Influences

Functional apparel is thought to focus on the functional aspects of a segment first and aesthetics second, yet this is not entirely accurate. Aesthetics can play a secondary role to functional aspects for many end-users' purposes in functional apparel; however, exceptions are clearly evident for sports and special groups, like those with disabilities or medical conditions. For these groups, aesthetics may be equal in importance to the functional aspects as their apparel is used to interact with individuals in their social structure and need to appear aesthetically similar to those in the group (Fatima & Paul, 2015; Fowler, 1999; Gupta, 2011a; Kabel et al., 2016; LaBat, Ryan, & Sanden-Will, 2016). Aesthetic preferences are also affected by the end-users' identity characteristics like age, gender, culture, or body shape. Identifying the individual aesthetic characteristics contributes to acceptance of the functional apparel. Prior studies have shown style, design, fashionability, and color were highly sought-after aspects in functional apparel, yet preferences for these aspects is highly subjective (Fowler, 1999; Mitchka et al., 2009; Tullio-Pow et al., 2011).

Pre-existing deterrents. These refer to opinions that the end-user has formed on why the apparel would not be considered for use, and can be impacted by current styles, affordability, ethical concerns, or the end-user's identity (Bhatt, Silverman, & Dickson, 2018; Chen-Yu & Seock, 2002; Sproles, 1979; Stokes & Black, 2012). Initially, end-users will decide if the apparel is acceptable to them or not before purchasing (Sproles, 1979). If the purchase has already been made, the end-user may change future usage of the apparel based on whether the first use was satisfactory according to a variety of variables, such as identity, aesthetics, quality, wearability, brand, and functionality (Abraham-Murali & Littrell, 1995; Casper, Gray, & Stellino, 2007; Chae, Black, & Heitmeyer, 2006; Sproles, 1979; Worland, Black, & Freeman, 2016). Because a variety of variables can form pre-existing deterrents, this study proposes the following research question:

> **Research question 1:** What perceived deterrents, if any, do parents have for using sun protective clothing on their child(ren)?

Personal style. The style of functional apparel has historically not been a primary concern in the design of functional apparel (Boorady, 2011; Watkins & Dunne, 2015). Yet for some functional apparel categories, such as sportswear, outdoor apparel, wearable technology, and apparel for those individuals with disabilities or medical conditions, personal style is a primary concern when the apparel is worn in a social setting (Chae & Evenson, 2014; Chae & Schofield-Tomschin, 2010; Fowler, 1999; Freeman et al., 1985; Mitchka et al., 2009; Morrissey & Rossi, 2013; Perry, Malinin, Sanders, Li, & Leigh, 2017; Sau-Fun, Chi-Leung, & Lai-Fan, 2011; Wingate, Kaiser, & Freeman, 1986). Fowler's (1999) findings reported style was ranked as the third most important attribute in sports apparel. This can be supported by other researchers' findings for snowboarding, ice hockey, golf, basketball, diving, and dance apparel, which all report on style being a consideration with their sports apparel (Boorady, 2006; Chae & Evenson, 2014; Chae & Schofield-Tomschin, 2010; Dionigi, 2002; Feather, Ford, & Herr, 1996; Kwok, Kong, & Fan, 1999; Mitchka et al., 2009). Smart apparel designers and users reported fashionability as one aspect for purchasing intentions (Hwang et al., 2016; Koo, Michaelson, et al., 2016; Perry et al., 2017). Individuals with disabilities have reported the need to look normal, fashionable, and attractive, so the style of functional apparel was important to them to maintain their identity and interact within their social roles (Carroll & Kincade, 2007; Chang, Zhao, Guo, Wang, & Gu, 2009; Fatima & Paul, 2015; Freeman et al., 1985; Kidd, 2006; Na, 2007; Stokes & Black, 2012; Wingate et al., 1986). Researchers studying hospital apparel found patients wanted modest and dignified apparel (Cho, 2006; Park, 2014; Power, Leaper, & Harris, 2017; Sau-Fun et al., 2011; Wong, Kwok, Chan, & Yeung, 1999). Individuals undergoing medical treatments, especially breast cancer, have expressed a need for better styles in sleepwear, swimwear, loungewear, sports bras, and headwear (Ghalachyan & MacGillivray, 2016; LaBat et al., 2016; Tullio-Pow et al., 2011). Based on prior research, style emerges as an important variable in functional apparel especially when it is worn in social or public settings. Hence, the following research question is proposed:

Research question 2: What are parental preferences for sun protective apparel styles in children?

End-User: Affordability

The cost of the functional apparel compared to the end-user's perception of affordability for the item is seldom investigated in all functional apparel categories. Chan et al. (2012) found that wearable technology for the elderly was deemed affordable. Yet, individuals with a disability reported that the affordability of functional apparel to be a significant concern based on their limited incomes and lower purchasing power in the marketplace (Na, 2007). Sportswear researchers have found that the cost of the item is an important factor in purchasing and the end-users want a good value for their purchase (Fowler, 1999; Lee, Jeong, & Kim, 2009; Michaelson, Teel, et al., 2018). Weiss and Weiss (2007) found the lower the perceived cost of a sport, including the apparel, the higher the commitment to the sport. While the research in each functional apparel category varied on affordability it is important to know how the end-user feels about the cost and perceived value they are receiving when purchasing functional apparel for specific needs. Hence, the following research question is posed:

Research question 3: Are children's sun protective apparel fulfilling the parents' expectations of affordability?

Task: Protection from sun

Ultraviolet damage during childhood accounts for approximately 80% of a person's total lifetime sun exposure (Preston & Stern, 1992). Children are unaware of the damage that ultraviolet rays can cause them (Donavan & Singh, 1999). Outdoor activities put children at an increased risk for overexposure; the leading cause of skin cancers is overexposure, and this is preventable with proper sun protection (Glanz & Mayer, 2005; Moehrle, 2008). Song and Stone (2005) found that adults understood the risks of overexposure to ultraviolet rays, yet they were not worried about overexposure enough to use sun protective apparel. Researchers have also reported sun protective clothing is the most effective sun protection, yet 16% or less actually wear protective clothing, and less than half of children properly wear sunscreen, resulting in overexposure (Koch, Pettigrew, Strickland, Slevin, & Minto, 2017; Linos et al., 2011). Donavan and Singh's (1999) research stated parental involvement was critical to instilling sun protective behaviors in children. While researchers have shown wearing sun protective apparel is the best protective option, not all individuals are aware that apparel provides the best protection against ultraviolet rays. Given the low rates of adoption of sun protective apparel, the following research question is investigated:

Research question 4(a): Are children's sun protective apparel fulfilling the parent's expectations for protection from sun?

Task: Compliance

Functional apparel can only perform if the end-user wears the apparel as recommended. Researchers found that police officers often did not comply with wearing their ballistic vest due to comfort issues (Barker & Black, 2009). Proper comfort and fit were factors with medical patients complying with using prescribed medical garments (Johnson, Greenspan, Gorga, Nagler, & Goodwin, 1994; O'Hare, 1997). Higher compliance can be found when the user understands the importance of wearing the garments and its impact on their health (Ripper, Renneberg, Landmann, Weigel, & Germann, 2009). Researchers have stated that sunscreen usage has increased in children due to parental understanding of the sun damaging rays, but little literature has been found on parents increasing usage of sun protective apparel (Glanz et al., 2008; Johnson, Davy, Boyett, Weathers, & Roetzheim, 2001; Koch et al., 2017). Understanding the current level of compliance is important when investigating functional apparel so that a baseline can be established for future research. Hence, the following question is posed:

Research question 4(b): Are parents complying with the usage of children's sun protective apparel?

Task: Textiles

Functional apparel design decisions for creating or analyzing apparel should include textiles as they impact the end-user physically, psychologically, and physiologically. Researchers and designers should understand fiber, structure, and finishing properties available for textiles along with various other material components (e.g. zippers, thread, snaps, buttons, cords, or elastic) needed to construct each specific functional apparel item. Functional factors related to textiles include fit, mobility, protection, durability, comfort, donning and doffing, and performance characteristics (Choi & Ashdown, 2002; Hayes & Venkatraman, 2016; Laing & Sleivert, 2002; Watkins & Dunne, 2015). Textiles can also impact stretch, drape, recovery, thermal and protective properties, and performance of functional apparel (Gupta, 2011a). Individual factor considerations for textiles would be printing, and design details as they can impact the style, aesthetics, and social and ethical concerns (Hayes & Venkatraman, 2016; McCann, 2015; McCann, Hurford, & Martin, 2005; Motlogelwa, 2018).

Limited functional apparel studies report on the end-user's knowledge of textile type, textile name, or fiber content. Additionally, apparel brands may have proprietary fibers or textiles and many only report the trademarked name or fiber content (Hayes & Venkatraman, 2016). Bye and Hakala's (2005) study on sailing apparel reported heavy and rough textiles resulted in poor fit and restricted mobility while high-end sailing apparel made of pliable textiles and incorporating stretch panels improved fit and performance but was expensive. Feather, Ford, and Herr (1996) found basketball uniform textiles were uncomfortable and caused players to chafe or feel the textile clinging to the body. The impact of textiles on the body causes a psychological effect that can affect the user's willingness to wear the apparel for the needed task. Given this, we ask:

Research question 4(c): Are children's sun protective apparel fulfilling the parent's expectations for textiles?

Design: Fit

Functional apparel fit is an individual's personal perception of how the apparel should lay, look, and move with the body (Ashdown & Delong, 1995; Barker & Black, 2009; Chen, LaBat, & Bye, 2010; LaBat & DeLong, 1990; Yu, 2004). Fit preference or actual fit can differ based on gender, age, size, body shape, cultural influences, ethnicity, lifestyle, religion, fabric properties, materials, joining techniques, fashion trends, functional purpose, and socio-psychological factors; all of these can change during an individual's lifetime (Boorady, 2011; Brown & Gallagher, 1992; Chattaraman & Rudd, 2006; Faust & Carrier, 2014; Hayes & Venkatraman, 2016; Hunter & Fan, 2004; LaBat & DeLong, 1990; Laing & Sleivert, 2002; McCann, 2016; Pisut & Connell, 2007; Shishoo, 2015; Tyler, Mitchell, & Gill, 2012; Watkins, 2011; Zakaria, 2016). Ideally, a properly fitted garment should hang smoothly on the end-user, not pull, sag, bind, or twist, be comfortable, and not impede the end-user from performing their task (Boorady, 2011; Bye & Hakala, 2005; Chae & Evenson, 2014; McCann, 2016; Tremblay-Lutter, Crown, & Rigakis, 1996; Wheat & Dickson, 1999). Providing proper fit can be complex with so many factors impacting it.

Reddy-Best & Harmon (2015) found girls and boys were concerned about the fit of their swimsuits especially if it exposed their body due to improper fit. Children were less likely to participate in sports, including swimming, due to ill-fitting clothing (Reddy-Best & Harmon, 2015). Ill-fitting clothing can also cause accidents in children, especially those with special needs

(Fatima & Paul, 2015). There are many factors that can cause improper fit, such as construction, textiles, or sizing (Zakaria, 2016). An improper fit can cause psychological and physical discomfort in children and can impact if they will wear the apparel (Power et al., 2017; Reddy-Best & Harmon, 2015; Shin, Smith, & Gaines, 2015). Teenagers are known to reject or adopt apparel based on their level of fit satisfaction (Ironico, 2012). Additionally, children grow at expedited rates at certain times in their life, which complicates the fit satisfaction as clothing that fit last week may not fit the same this week (Zakaria, 2016) As parents or caregivers are typically responsible for purchasing, and at times dressing children, it is important that expectations of fit are investigated for sun protective apparel.

Research question 5(a): Are children's sun protective apparel fulfilling parents' expectations for fit?

Design: Body Shape

A child's body shape impacts fit as they, or their parent, may have a difficult time choosing a size, or the apparel style may not fit their body shape (Faust & Carrier, 2014; Song & Ashdown, 2013; Zakaria, 2016). Body shape can be based on age, gender, ethnicity, genetics, muscle structure, height, and weight making it difficult for apparel manufacturers to size apparel when their end-users vary in these areas (Faust & Carrier, 2014; Schofield, Ashdown, Hethorn, LaBat, & Salusso, 2006; Song & Ashdown, 2013; Zakaria, 2016). Research has shown that children have different body shapes mainly due to their height and weight (Faust & Carrier, 2014; Reddy-Best & Harmon, 2015; Zakaria, 2016). As children start puberty, body shape is impacted by gender, age, genetics, and muscle structure (Zakaria, 2016) Children and teenagers who are dissatisfied with their body shape may have problems with apparel fit, and this is especially true with those who are overweight (Chen, Fox, & Haase, 2008; Reddy-Best &

Harmon, 2015). As body shape can impact fit, it is good to understand at what levels body shape expectations are being fulfilled in an apparel category so that fit can be better understood.

Research question 5(b): Are children's sun protective apparel fulfilling parents' expectations for body shape?

Design: Mobility

Sun protective apparel is typically worn in the water and should allow the body to freely move while in the water (Watkins & Dunne, 2015). Researchers have reported that restricted movement may contribute to discomfort, bodily pain and/or injury (Huck, 1988; Kwok, Kong, et al., 1999; Stokes & Black, 2012). Movement in the water can also cause sports apparel to move on the body, creating unnecessary body exposure which may not be desired by the end-user (Kwok, Kong, et al., 1999; Reddy-Best & Harmon, 2015). Body exposure is a common problem when jumping or diving into the water (Kwok, Kong, et al., 1999). Consumers from the recreational to professional level rely on sports apparel to not impair mobility or cause any problems associated with their activity; thus, researchers investigate mobility on a regular basis (Chae et al., 2006; Hayes & Venkatraman, 2016; Kwok, Kong, et al., 1999; Morrissey & Rossi, 2013; Reddy-Best & Harmon, 2015). Hence, we pose the question:

Research question 5(c): Are children's sun protective apparel fulfilling parents' expectations for mobility?

Design: Durability

Sun protective apparel is repeatedly donned, doffed, laundered, exposed to chemicals in water, and moved in, so durability is a concern for end-users (Hunter, 2009; Motlogelwa, 2018). Hunter (2009) stated that durability is a combination of fiber type, fabric, and garment construction. Fowler's (1999) study on sport attributes found apparel durability to be important to athletes. This is supported by sportswear researchers who reported snags and abrasion on fabrics as durability factors (Bye & Hakala, 2005; Jung & Chun, 2013; Michaelson, 2015). As children can spend several hours each week in the water wearing the same apparel, durability can be a problem due to laundering, movement, donning and doffing, and the sun protective apparel's exposure to water chemicals (Dadlani & Orlow, 2008; Donavan & Singh, 1999; Hunter, 2009; Motlogelwa, 2018).

Research question 5(d): Are children's sun protective apparel fulfilling parents' expectations for durability?

Design: Comfort

Researchers found sensory/tactile comfort responses in a variety of children's functional apparel, such as for sports apparel and apparel for individuals with medical and special needs (Bergen et al., 1996; Fatima & Paul, 2015; Power et al., 2017; Reddy-Best & Harmon, 2015; Zakaria, 2016). A child's perceptions of psychological comforts – sensory, tactile, and thermoregulation – occur when the apparel contacts the skin and elicits a response (Branson & Sweeney, 1991; Das & Alagirusamy, 2010; Kamalha, Zeng, Mwasiagi, & Kyatuheire, 2013; Pineau, 1982). The child may express how the physical comfort of the textile feels against the skin with terms such as, smooth, rough, scratchy, itchy, thick, thin, stiff, and heavy (Das & Alagirusamy, 2010). Thermoregulatory responses can result if the child becomes too hot or cold and he or she expresses feelings of being chilly, hot, damp, sticky, clingy, or wet (Das & Alagirusamy, 2010; Hollies, Custer, Morin, & Howard, 1979; Kamalha et al., 2013). This type of thermoregulatory response is also observed regularly with sports or other intensive physical activities that cause the skin moisture to become trapped between the skin and clothing creating discomfort for the wearer (Das & Alagirusamy, 2010; Ho, Fan, Newton, & Au, 2011; Laing &

Sleivert, 2002). Thermoregulation during physical activities, such as swimming or playing in water, is important for thermal balance and comfort (Fan & Tsang, 2008; Gavin, 2003; Kwok, Kong, et al., 1999; Morrissey & Rossi, 2013). If comfort can be optimized in sun protective apparel, the child will not be distracted by the apparel, and can perform activities or play in the water with limited distractions (Ashdown, 2011; Ho et al., 2011; Kamalha et al., 2013; Roy Choudhury, Majumdar, & Datta, 2011). Hence, the following research question is proposed:

Research question 5(e): Are children's sun protective apparel fulfilling parents' expectations for comfort?

Design: Donning and Doffing

The ease of getting into and out of apparel, also known as dressing, is a common problem for caregivers or children based on age, special needs, or medical conditions (Kwok, Harlock, Tam, & Lo, 1997, 1998; Stokes & Black, 2012; Watkins & Dunne, 2015). Researchers found that athletic apparel can be problematic as the fabric adhers to the body after activity due to moisture; thereby making it more difficult to doff it after use (Boorady, 2006; Bye & Hakala, 2005; Davis & Bishop, 2013; Kwok, Kong, et al., 1999). Disabled individuals experience a range of problems with donning and doffing clothing depending on their type of disability (Carroll & Kincade, 2007; Chang et al., 2009; Curteza, Cretu, Macovei, & Poboroniuc, 2014; Fatima & Paul, 2015; Kabel, Dimka, & McBee-Black, 2017; Na, 2007; Pompelli, 1998; Rusk & Taylor, 1959; Stokes & Black, 2012; Wang et al., 2014). Age and medical conditions impact dexterity of dressing especially with infants, hospital apparel, and medical patients (Bergen et al., 1996; Kwok et al., 1997; Sperling & Karlsson, 1989; Wong et al., 1999). The ease of the donning and doffing process should be investigated to assess if there are any needs for children wearing sun protective apparel.

Research question 5(f): Are children's sun protective apparel fulfilling parents' expectations for donning and doffing ease?

Production: Sizing system

Communicating sizing starts with a sizing chart and label that matches the consumers' measurements and is required to be placed inside the apparel (Brown & Rice, 2013; Faust & Carrier, 2014). Parents and caregivers rely on a sizing system to make decisions about apparel, and for children they should use weight, height, and body measurements in order to relate to the proper sizing system (Chun, 2007). Sizing systems vary by country, and each country has a different sizing system based on that population's measurements, such as the United States, United Kingdom, Canada, Korea, and China (Bellemare, 2014; Yu, 2004). Sizing charts can aid the parent or caregiver in choosing the correct size for their child (see Figure 5). The sizing

BABY APPAREL

US / METRIC

Size	Height (in)	Weight (lb)
P up to 5 lb	Up to 17"	Up to 5 lb
P (Preemie)	Up to 18"	Up to 6 lb
NB (Newborn)	18-21.5"	6-9 lb
3M	21.5-24"	9-12.5 lb
6M	24-27"	12.5-17 lb
9M	27-28.5"	17-21 lb
12M	28.5-30"	21-25 lb
18M	30-32"	25-28 lb
24M	32-34"	28-30 lb

Figure 5. Baby apparel size chart (Carter's, 2019)

systems for children start at birth and changes as the child ages, grows, and matures (Brown & Rice, 2013; Zakaria, 2016). The U.S. children's wear sizing system uses height and weight from birth to 6X/7, and then changes to a gender sizing system (girls/boys) identified by height, chest, waist, and hip measurements in inches (Brown & Rice, 2013; Carter's, 2019). Researchers have reported that not everyone knows how to properly take body measurements, which poses a problem when the end-user is trying to choose the proper size (Chun, 2007; Song & Ashdown, 2013). Additional problems have been reported when body measurements fall into different sizes, thereby posing a challenge for end users in finding the appropriate size as they fall into more than one size (Song & Ashdown, 2013; Zakaria, 2016). Given the problems in sizing for children, the following research question is investigated:

Research question 6(a): Are children's sun protective apparel fulfilling parents' expectations for a sizing system?

Production: Construction

Apparel construction relies on fabrics, materials, joining techniques, stitch type, stitch strength, and thread to achieve the desired level of durability and quality (Kunz & Glock, 2004; Rogale, Bobovcan Marcelic, Rogale, Dragcevic, & Nikolic, 2012). Sun protective apparel typically uses stretch textiles which require specific joining techniques, stitches, and thread to allow for stitch elasticity (Kunz & Glock, 2004; McLoughlin & Hayes, 2015). Textured polyester or textured nylon thread can also be used to increase seam softness and comfort (Kunz & Glock, 2004). Seam comfort can directly impact fit when discomfort is experienced (Fatima & Paul, 2015; Ho & Au, 2016). Durability and quality are factors impacted during a seam failure that can result in the apparel causing discomfort, improper fit, or bodily exposure (Kwok, Kong, et al., 1999). If construction is poor it impacts fit, comfort, durability, and quality thereby not meeting the end-users' expectations (Brown & Rice, 2013), which leads us to investigate the following question:

Research question 6(b): Are children's sun protective apparel fulfilling parents' expectations for apparel construction?

Production: Quality

The perception of quality in sun protective apparel can consist of many factors, such as apparel construction, textiles, joining techniques, longevity of apparel, and many more. Researchers have investigated various quality factors in functional apparel, but some were not specific in regard to the type of quality factors (Mitchka et al., 2009). Some researchers have asked end-users to rate apparel on a semantic scale of low to high quality (Barker & Black, 2009; Black & Cloud, 2008). Others investigated quality based on the construction of the apparel (Bye & Hakala, 2005; Choi & Ashdown, 2002; Perry & Lee, 2017; Wheat & Dickson, 1999). The perception of quality also changes over time with laundering (Black & Cloud, 2009; Bye & Hakala, 2005; Perry & Lee, 2017; Sau-Fun et al., 2011). To understand the level of quality needed in sun protective apparel, researchers should incorporate the appropriate measures into the research design, so that a true understanding of the end-user's perceptions of quality of sun protective apparel can be achieved.

Research question 6(c): Are children's sun protective apparel fulfilling parents' expectations for apparel quality?

Production: Ease of Care

The ease of care can involve the understanding of care labels, stain removal, laundering procedures, pressing, and storage of functional apparel (Nayak & Padhye, 2015). Apparel are required to have care labels so that the end-users know how to properly care for garments (Brown & Rice, 2013). Properly caring for apparel can extend the overall life of the garment (Brown & Rice, 2013). Sportswear users have reported that they desire apparel that is easy to care for and maintains its shape after multiple washings (Fowler, 1999; Kwok, Kong, et al., 1999; Lee et al., 2009; Mitchka et al., 2009; Wheat & Dickson, 1999). Multiple washings can affect a textile's elasticity and seam durability (Kwok, Kong, et al., 1999). As sun protective apparel is laundered multiple times, especially during the summers, to remove chemicals, environmental hazards, and sunscreen, the ease of care expectations could be a factor in sun protective apparel usage. To address this, we propose the following research question:

Research question 6(d): Are children's sun protective apparel fulfilling parents' expectations for the ease of care?

Production: Availability

Sun protective apparel is a new apparel item introduced in the 1990's for medical purposes (Food and Drug Administration, 1992). The availability of apparel can impact end-users when their sizes are not available for purchase (Chae et al., 2006; Chen-Yu & Seock, 2002). Chen-Yu and Seock (2002) reported product availability was more important to adolescent girls than boys. Overweight and obese individuals reported the lack of available sportswear in plus sizes lead to embarrassment and the wearing of an improper size (Christel, O'Donnell, & Bradley, 2016; Reddy-Best & Harmon, 2015). Problems with the availability of sportswear is seen with apparel lengths, such as pant, back, or sleeve lengths, and have been reported with many sports, such as ice hockey, rock climbing, sailing, golf, basketball, and tennis players (Boorady, 2006; Bye & Hakala, 2005; Chae & Evenson, 2014; Feather et al., 1996; Jin & Black, 2012; Michaelson, 2015; Wheat & Dickson, 1999). Manufacturers and designers of sun protective apparel should realize the importance product availability to end-users. Given the lack of research, it is not known if product availability expectations are being fulfilled for sun protective apparel end-users.

Research question 6(e): Are children's sun protective apparel fulfilling parents' expectations for the availability?

Case Study 2 – Wildland Firefighters' Perceptions of NFPA 1977 Protective Apparel

Purpose

The purpose of case study 2 was to apply the Multidimensional Functional Apparel Framework (MFAF) to investigate wildland firefighters' perceptions of their NFPA 1977 Protective Clothing along with any perceived functionality differences between NFPA 1977 apparel editions (see Figure 6). The end-user dimension was applied to investigate wildland fire

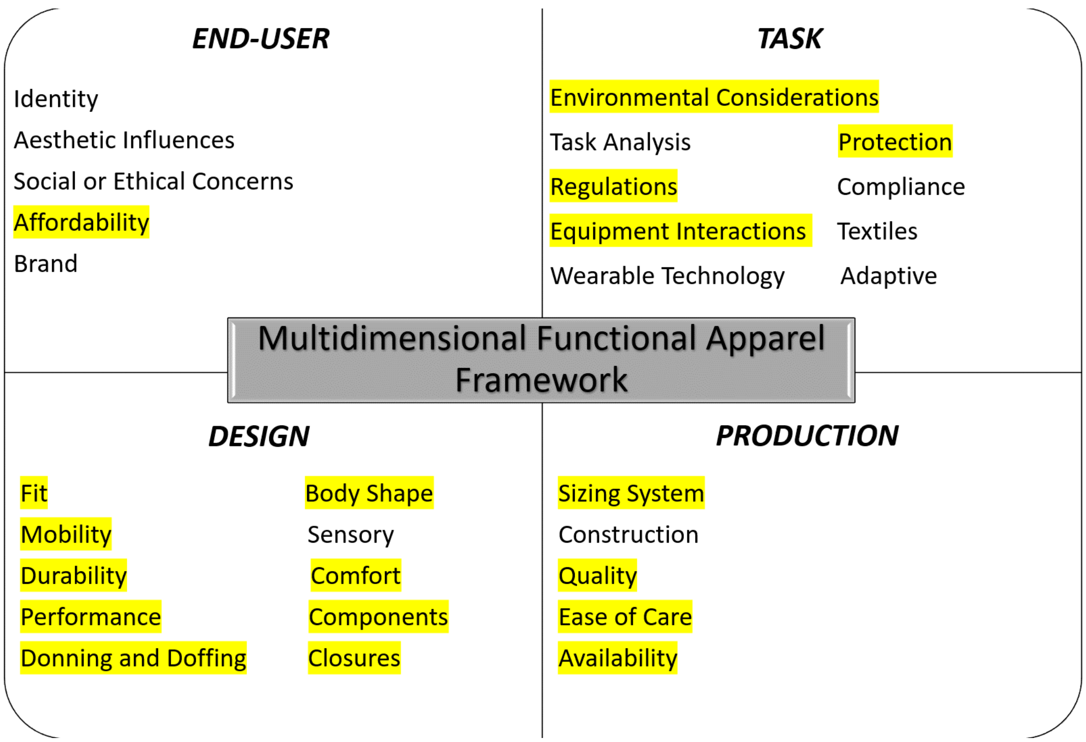


Figure 6. Application of Multidimensional Functional Apparel Framework to Case Study 2

fighters' perceptions of NFPA 1977 Protective Clothing affordability. The task dimension was applied to wildland firefighters' environmental work considerations, perceptions of NFPA 1977 Protective Clothing protection, perceived functionality differences between NFPA 1977 regulation apparel editions, along with equipment interactions. The design dimension was applied in context to wildland firefighters' perceptions of NFPA 1977 Protective Clothing fit, interactions with user's body shape, mobility perceptions, durability factors, comfort perceptions, performance perceptions, donning and doffing ease, and perceptions of NFPA 1977 Protective Clothing components and closures. The production dimension investigated wildland firefighters' perceptions of their NFPA 1977 Protective Clothing sizing system, perceived quality, ease of care, and availability of NFPA 1977 Protective Clothing and its editions.

End-User: Affordability

Wildland firefighters are required to wear NFPA 1977 Protective Clothing while working wildland firefighting (National Fire Protection Association, 2016). Wildland firefighters are employed at a national level, state level, and through the private agencies. Depending on who employs the wildland firefighters, NFPA 1977 Protective Clothing may be provided by the employers or wildland firefighters may be required to purchase their own apparel. It has been reported that a wildland firefighter's entire gear could cost approximately $2,700, with specialized shirts being about $150 a piece and pants varying from $200-$300 each (see Figure 7) (Edge, n.d.). As the required apparel may or may not have to be purchased by the wildland firefighters, affordability perceptions could vary and should be investigated.

Figure 7. Cost of outfitting a wildland firefighter (Edge, n.d.)

Research Question 1(a): What are wildland firefighters' perceptions of their NFPA 1977 Protective Clothing for affordability?

End-User: Environmental Considerations

Apparel has been used to protect the body from environmental elements for over 100,000 years. The interaction of the environment and body affects how the body thermoregulates and apparel can help this process. Performing a task in some environments, for any period, can require apparel designed for the specific elements, such as heat, cold, wind, humidity, and rain, found in the environment. An understanding of the environmental conditions in which the apparel will be used, along with the body response, is important when researching apparel.

Researchers have investigated US wildland firefighter protective apparel in a variety of arid outdoor environments. The arid climate zone has a mean temperature of 64°F, and features steppe and desert sub-climates that have hot and cold seasons (Kottek, Grieser, Beck, Rudolf, & Rubel, 2006). Firefighters in these climates deal with wildland, grass, or bush fires and requires specialized and regulated apparel as the apparel is flame retardant yet allows for some evaporative cooling (Budd et al., 1997; Huck & Kim, 1997; Rucker, Anderson, & Kangas, 2000a). Garment bellows with style ventilation incorporated into light, loose clothing aided firefighters in their thermal comfort while working wildland fires (Budd et al., 1997). Researchers working on protective clothing cooling systems have so far been unsuccessful in developing a cooling system that is adequate (Pandolf, 1995; Teunissen et al., 2014). Advances in air-ventilated garments showed an improvement in evaporative cooling when exercising soldiers wore air-ventilated vests, and no skin discomfort was reported (Barwood, Newton, & Tipton, 2009). Studies on hybrid personal cooling systems found these systems to be effective in cooling active individuals in arid climates, but the systems were cost prohibitive at the time (Lu et al., 2015; Song & Wang, 2016; Teunissen et al., 2014).

Task: Protection

The primary function of protective apparel is to keep wildland firefighters safe from a variety of environmental harms and from any equipment being used (Fenne, 2005; Gupta, 2011b; Watkins & Dunne, 2015). Various functional apparel aspects of the apparel, such as fit, textiles, and durability, ensure this protective apparel optimally protects the wildland firefighter by limiting problematic areas in apparel that may cause a safety problem (Gupta, 2011a, 2011b; Hayes & Venkatraman, 2016; Watkins & Dunne, 2015). Firefighters reported poor fit including inadequate sizing systems, thermal comfort, visibility, and mobility issues, along with a loss of performance while wearing protective apparel (Coca, Williams, Roberge, & Powell, 2010; Havenith & Heus, 2004; Park, Park, Lin, & Boorady, 2014; Rucker, Anderson, & Kangas, 2000b). The durability of protective apparel can result in the end-user being injured or unprotected to future injuries when the textile or construction of the apparel fails (Boorady, Haise, Rucker, & Ashdown, 2009; Huck & Kim, 1997). Textiles and durability can provide additional protection from tears, punctures, and various environmental factors (Buckley, 2005; Dammacco, Turco, & Glogar, 2012; Hearle, 2005; Watkins & Dunne, 2015). It is the incorporation of fit, textiles, and durability factors with the protective apparel that allows it to provide a higher level of protection for the wildland firefighter.

Research question 2(a): What are wildland firefighters' perceptions of the NFPA 1977 Protective Clothing for their protection ability?

Task: Regulations

Regulations are a set of codes, standards, practices, or guidelines that govern various aspects of apparel and may address assorted components, characteristics, or behaviors, such as textiles, sizing, seam strength, labeling, testing, or advertising. Regulations vary by government agency, trade association, and organization. Adherence to regulations typically ensure users' safety by protecting them from various physical or environmental harms; they also may be in place to insure manufacturing consistency for all users. Manufacturers for wildland firefighters must adhere to the most current edition of NFPA's 1977 "Standard on Protective Clothing and Equipment for Wildland Fire Fighting" (National Fire Protection Association, 2016). This standard informs manufacturers about garment specifications and testing procedures, which must be followed prior to being sold to wildland firefighters. Under this standard, all wildland firefighting protective apparel must have a sewn-in label that states it meets the requirements of the NFPA 1977, including the edition, manufacturer certifications, type of garment, size, manufacturing location, fiber content, and care instructions (see Figure 8).

Figure 8. Wildland Fire Fighting Pants NFPA 1977 – 2011 Edition Label, Personal Collection, ©2018 Dawn Michaelson

(National Fire Protection Association, 2016). Researchers should always investigate if the proper regulation is in place prior to making changes to the functional apparel. NFPA 1977 Protective Clothing editions are 2005, 2011, and 2016 for both the wildland firefighters protective shirt and pant.

Research question 2(b) What are wildland firefighters' perceptions of the regulations that govern the NFPA 1977 Protective Clothing?

Research Question 5. Are there any preferences for a specific NFPA 1977 edition apparel?

Task: Equipment Interactions

Equipment interactions with apparel can cause impairment and psychological implications for workers (Laing & Sleivert, 2002; Watkins & Dunne, 2015). Firefighters often wear protective equipment which has been reported to restrict body movement, impair vision, limit dexterity, cause overheating, increase the risk of bodily injury, and perhaps impair their ability to properly perform their job (see Figure 9) (Havenith & Heus, 2004; Huck & Kim, 1997; Park & Hahn, 2014; Park et al., 2014). Huck and Kim (1997) reported fit, sizing, comfort, and mobility were functional factors needed when designing grassland firefighting apparel. Wildland firefighters are required to wear a hard hat, gloves, boots, specialized shirt and pants, an emergency pack, communications radio, a fire shelter, and may also need to carry a Pulaski tool, Rhino tool, Combi tool, chainsaw, chainsaw fuel, tool sharpener, headlamp, goggles, food, water, and personal items (Edge, n.d.; Hayden, 2017; Puckett, 2018). Special attention should be placed on the protective apparel as wildland firefighters may use a variety of equipment that can interact with their NFPA 1977 protective apparel.

Figure 9. Wildland firefighter gear (Hayden, 2017)

Research question 2(c): What are wildland firefighters' perceptions of their NFPA 1977 Protective Clothing based on equipment interactions?

Design: Fit

NFPA 1977 regulations specify sizing, measurements, and ease allowances for wildland firefighter protective apparel (National Fire Protection Association, 2016). Fit is a common problem in firefighting apparel and fit satisfaction can have an impact while performing tasks (Choi & Ashdown, 2010; Coca et al., 2010; Huck & Kim, 1997; Park & Hahn, 2014; Park et al., 2014; Parker, Vitalis, Walker, Riley, & Pearce, 2017). Fit problems are not exclusive to firefighters and can be found in other occupational protective apparel. Barker and Black (2009) found that ballistic vests had proper fit in a standing position but rode up the body causing neck discomfort and improper fit while sitting. Other researchers found similar fit problems with bicycle patrol officers, farmers, pesticide applicators, protective overalls wearers, and the military while they were completing tasks (Black & Cloud, 2008; Boorady et al., 2009; Choi & Ashdown, 2002; Huck, Maganga, & Kim, 1997; Rucker et al., 2000b; Rutherford-Black & Khan, 1995).

Women also have fit issues with their protective apparel in many different body areas (Bye & Hakala, 2005; Kwok, Kong, et al., 1999). Fit with women's functional apparel can be more problematic when the apparel was originally designed for men and then adapted for women because mobility, comfort, and performance can be impaired due to improper fit (Barker & Black, 2009; Bye & Hakala, 2005; Laing & Sleivert, 2002). Feather et al. (1996) reported female basketball players had low fit satisfaction with hip, crotch, and buttocks. Chae and Evenson (2014) found mature women had fit problems with shoulders, armholes, and the waist in golf apparel due to body changes as women age. Fit problems are not only specific to women; men, children, and teenagers have also reported problems with fit in functional apparel (Barker & Black, 2009; Chun, 2007; Jin & Black, 2012; Zakaria, 2016).

Research question 3(a): What are wildland firefighters' perceptions of the fit of their NFPA 1977 Protective Clothing?

Design: Body Shape

An individual's body shape impacts fit, and wildland firefighters may have a difficult time choosing a size to fit their body shape (Faust & Carrier, 2014; Song & Ashdown, 2013). Body shape can be based on age, gender, ethnicity, genetics, muscle structure, height, and weight, making it difficult for NFPA 1977 manufacturers to size protective apparel for wildland firefighters (Faust & Carrier, 2014; National Fire Protection Association, 2016; Schofield et al., 2006; Song & Ashdown, 2013; Zakaria, 2016). Stunkard, Sorensen, and Schulsinger (1983) developed a range of silhouettes from thin to obese to aid researchers in identifying their participants' body shape perception (see Figure 10). Research has shown that

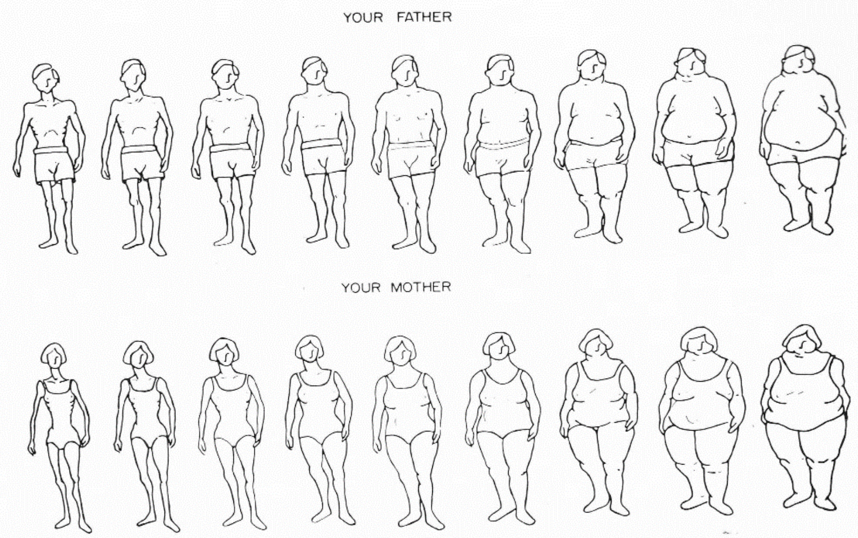


FIG. 2. Nine silhouettes of men and women ranging from very thin to very fat. Adult offspring pick the silhouette that most closely corresponds to the usual and to the most obese silhouette of their fathers and mothers. Validation studies show a high degree of correspondence between these choices and percentage overweight of the parents as determined by measurements of height and weight.

Figure 10. Body shape silhouettes for males and females (Stunkard et al., 1983)

overweight or obese individuals have different body shapes due to their weight (Christel et al., 2016; Faust & Carrier, 2014). Additionally, ageing affects the body shape in numerous ways, like shoulder rounding, bust girth increases, neck sagging, and back curvature (Faust & Carrier, 2014; McCann & Bryson, 2015). Researchers have examined body shape and have reported that when apparel manufacturers produce apparel for specific end-users based on their body shape, they have higher customer retention (Faust & Carrier, 2014; Song & Ashdown, 2013). While wildland firefighters may be required to pass a physical fitness test, this does not guarantee all firefighters have the same body shape (U.S. Forest Service, 2002).

Research question 3(b): What are wildland firefighters' perceptions of their NFPA 1977 Protective Clothing based on body shape?

Design: Mobility

Protective apparel should allow the body to freely move while doing required work tasks (Watkins & Dunne, 2015). Specific tasks required for an occupation, such as wildland firefighting, relies on the end-user having the ability to move freely while wearing the protective apparel and equipment (Ashdown, 2011; Boorady, 2011; Coca et al., 2010; Park & Hahn, 2014; Park et al., 2014). Researchers have reported that protective apparel has restricted movement, limited mobility, impacted performance, affected the level of protection, and may even have contributed to bodily pain and/or injury (Adams & Keyserling, 1996; Barker & Black, 2009; Carlton, Orr, Stierli, & Carbone, 2013; Coca et al., 2010; Gon & Paul, 2011; Huck, 1988; Huck et al., 1997; Park & Hahn, 2014; Park et al., 2011). Biomechanics of the human body can aid in the improvement of mobility in functional apparel by giving researchers an understanding of the movement of skin, muscles, joints, and tissues required for each task (Cheung & Zhang, 2006; Gupta, 2011a; Luximon & Zhang, 2006; McGhee, Steele, Zealey, & Takacs, 2013). Researchers have found that the functional apparel, including equipment, necessary for a task can impact mobility especially with protective apparel, such as gloves, helmets, and firefighting equipment (Boorady et al., 2009; Carlton et al., 2013; Chae & Schofield-Tomschin, 2010; Havenith & Heus, 2004; Huck, 1988; Huck & Kim, 1997; Huck et al., 1997; Koo, Teel, & Han, 2016; Tremblay-Lutter et al., 1996). Movement task analyses investigate the required range of movements for each task that needs to be accomplished by the end-wearer (Boorady, 2011; Watkins & Dunne, 2015). Researchers using task analyses have reported that mobility was impacted for police ballistic vests, farm workers, firefighters, meat-cutters, and individuals in the military (see Figure 11) (Barker & Black, 2009; Choi & Ashdown, 2002; Coca et al., 2010; Ilmarinen et al., 1990; Park & Hahn, 2014; Park et al., 2011; Tan et al., 1998).

Figure 11. Firefighter performing one arm task in laboratory setting (Coca et al., 2010)

Research question 3(c): What are wildland firefighters' perceptions of their NFPA 1977 Protective Clothing with respect to mobility?

Design: Durability

Wildland firefighters protective apparel is repeatedly donned, doffed, moved in, laundered, and exposed to a wide variety of environmental hazards, so durability may be a factor (Hunter, 2009; Motlogelwa, 2018). Durability tests should be specific to the end-user needs, and tests may be based on dimensional stability, stretch recovery, and abrasion resistance, but also the users' movements and environmental hazards (Hayes & Venkatraman, 2016; Motlogelwa, 2018; National Fire Protection Association, 2016). Many sport and occupational protective apparel can be expensive, so understanding durability factors to extend the life of the apparel may also need to be known for wildland firefighters (Edge, n.d.; Jung & Chun, 2013; May-Plumlee & Pittman, 2002; Michaelson, 2015).

Research question 3(e): What are wildland firefighters' durability perceptions of their NFPA 1977 Protective Clothing?

Design: Comfort

Apparel comfort has been researched by investigating psychological, physiological, and physical aspects and perspectives along with how they affect the end-user in the environment (Branson & Sweeney, 1991; Das & Alagirusamy, 2010; Kamalha et al., 2013; Markee & Pedersen, 1991; Roy Choudhury et al., 2011; Slater, 1985). Comfort can be problematic to measure as the term is both relative and subjective to each end-wearer (Branson & Sweeney, 1991; Markee & Pedersen, 1991; Slater, 1985). All comfort components should be investigated with the understanding that measures of comfort terms can overlap (Markee & Pedersen, 1991). Psychological comfort contains sensory/tactile and thermoregulation aspects, physical comfort encompasses textile, fit, and pressure aspects, while physiological comfort has thermo-physiological, age, gender, health, weight, and activity level aspects (Branson & Sweeney, 1991; Das & Alagirusamy, 2010). The difficulties with researching comfort in apparel is that psychological and physiological measures may contain thermoregulatory terms and then the psychological tactile and physical comfort terms may also overlap when being researched (Kamalha et al., 2013; Michaelson, 2015). For example, a researcher got a stiffness or rough response from a participant, the researcher may not know how to accurately classify the comfort aspects because it may be a psychological tactile response or a physical response (Kamalha et al., 2013; Michaelson, 2015). The same can be true for thermoregulatory responses as they overlap into psychological and physiological responses (Laing & Sleivert, 2002; Michaelson, 2015). Thermoregulatory responses can result if the end-user becomes too hot or cold and they express feelings of being chilly, hot, damp, sticky, clingy, or wet (Das & Alagirusamy, 2010; Hollies et al., 1979; Kamalha et al., 2013). This type of thermoregulatory response is observed regularly with intensive physical activities that cause the skin moisture to become trapped between the skin and clothing, creating discomfort for the wearer (Das & Alagirusamy, 2010; Ho et al., 2011; Laing & Sleivert, 2002; Park et al., 2014).

Physiological comfort is the body's thermal regulatory process to produce or reduce body heat (Kamalha et al., 2013; Laing & Sleivert, 2002; Slater, 1985). Physiological comfort aspects involve thermo-physiological, age, gender, health, and activity levels (Das & Alagirusamy, 2010; Kamalha et al., 2013; Laing & Sleivert, 2002). Thermo-physiological comfort applies to the way apparel lets through or retains heat and moisture to help or not help the body retain a balance while in rest or during activities. A variety of thermo-physiological factors can affect the end-user, such as environmental factors (wind, temperature, and humidity), apparel performance (insulation, wicking, and air permeability), and the level of activity being performed (Das & Alagirusamy, 2010; Laing & Sleivert, 2002; Watkins & Dunne, 2015). Researchers have found gender can impact physiological comfort; women perceive comfort differently, especially those who can be affected faster (An & Domina, 2015; Fowler, 1999; Ho et al., 2009; Hooper et al., 2015; LaBat et al., 2016; Sontag, 1986). Individual health and weight affects physiological comfort based on blood volume, surface area, and thermal conductivity (Carroll & Kincade, 2007; Fatima & Paul, 2015; LaBat et al., 2016; Power et al., 2017; Sau-Fun et al., 2011; Stokes & Black, 2012). The physical activity level can greatly affect physiological comfort as sweat and higher body temperature are the direct result of intense activity, which has been seen in firefighters (Havenith & Heus, 2004; Ho et al., 2011). Thermo-physiological, age, gender, weight and health all contribute to physiological comforts whether it is from heat, humidity, or wind (Das & Alagirusamy, 2010; Kamalha et al., 2013; Laing & Sleivert, 2002). Each of these factors contribute to how well the end-user's body can handle blood flow to maintain internal body temperatures with different environments, physical activity that affects the body heat equilibrium, wearer's mental state, performance, and comfort (Das & Alagirusamy, 2010; Ho et al., 2011; Kamalha et al., 2013; Laing & Sleivert, 2002; Watkins & Dunne, 2015). If comfort can be optimized in functional apparel, the end-user will not be distracted by the apparel, and can perform tasks with no distractions from the apparel (Ashdown, 2011; Ho et al., 2011; Kamalha et al., 2013; Roy Choudhury et al., 2011).

Research question 3(d): What are wildland firefighters' perceptions of their NFPA 1977 Protective Clothing with respect to comfort?

Design: Performance

The performance of functional apparel can be investigated to evaluate the efficiency of tasks and activities being completed. Performance is sometimes researched through experimentation. Some investigate the end-users' perceived performance enhancement with the apparel (Dickson & Pollack, 2000; Hayes & Venkatraman, 2016; Ho et al., 2009) Functional apparel users, especially athletes, want to be efficient in their tasks, and proper functional apparel enables efficiency (Bye & Hakala, 2005; Choi & Ashdown, 2002; Dickson & Pollack, 2000; Perry & Lee, 2017; Wheat & Dickson, 1999). Fabric selection in sports apparel has been shown to decrease and improve performance of functional apparel (Chan et al., 2015; Davis & Bishop, 2013; Kwok, Kong, et al., 1999). In sports, performance apparel is highly sought after so the athlete can enhance their performance while competing (Hayes & Venkatraman, 2016). Performance stretch fabrics have been shown to improve an athlete's performance (Hayes & Venkatraman, 2016; Laing & Sleivert, 2002). Specifically, divers found fabric selection for their swimwear impacted their swimming performance (Kwok, Kong, et al., 1999). Additionally, the type of material used in protective gloves improved performance due to increased dexterity (Tremblay-Lutter et al., 1996). The environment, comfort, and fit of functional apparel has been shown to impact an end-users' performance, as well (Bye & Hakala, 2005; Wheat & Dickson, 1999). Researchers of ballistic and tactical vests, construction apparel, and firefighting gear all found heat stress caused a decrease in performance (An & Domina, 2015; Carlton et al., 2013; Chan et al., 2015; Park et al., 2014). Designers have stated they want to increase performance effectiveness in functional apparel to better aid the end-users, and research can provide answers for them (Perry et al., 2017).

Research question 3(f): What are wildland firefighters' perceptions of their NFPA 1977 Protective Clothing with respect to performance?

Design: Donning and Doffing

The ease of getting into and out of firefighting apparel is a documented problem for firefighters (Coca et al., 2010; Makinen, 2005; Park & Hahn, 2014; Parker et al., 2017; Watkins & Dunne, 2015). Other types of protective apparel, such as wetsuits or spacesuits, have been found to be difficult to don and doff and at times requires help from other individuals (Bitterman, Ofir, & Ratner, 2009; Gon & Paul, 2011; Han et al., 2015; Khanna & Kaur, 2013; Watkins & Dunne, 2015). Researchers have found problems with textiles adhering to the body after activity due to moisture; thereby making it more difficult to doff the apparel than don it (Boorady, 2006; Bye & Hakala, 2005; Davis & Bishop, 2013; Kwok, Kong, et al., 1999). Researchers also found donning and doffing was critical for protective and safety features for military, police, flightsuits, meat-cutters, firefighters, and chemical-biological suits (Barker & Black, 2009; Boorady et al., 2009; Havenith & Heus, 2004; Ilmarinen et al., 1990; Shanley et al., 1993; Tan et al., 1998; Tremblay-Lutter et al., 1996; Watkins & Dunne, 2015). Age has been known to impact dexterity with donning and doffing apparel (Mahoney et al., 2015; Sau-Fun et al., 2011; Schulte, 2015). Wildland firefighting apparel features a variety of closures, such as zippers, snaps, and hook and loop tape, to aid in the donning and doffing process (National Fire Protection Association, 2016). The actual donning and doffing ease should be investigated to assess if the needs of the wildland firefighters are being fulfilled.

> **Research question 3(g):** What are wildland firefighters' perceptions of their NFPA 1977 Protective Clothing with respect to donning and doffing ease?

Design: Components

There are a variety of functional apparel components, such as pockets, hoods, gussets, articulated knees, along with accessories and trims that should be considered to aid wildland firefighters in their tasks (Gupta, 2011a; Watkins & Dunne, 2015). Pockets are a commonly needed item in functional apparel, but the location, type, size, and closure can impact the end-user (Ahsan & Tullio-Pow, 2015; Anand, 2011; Black & Cloud, 2008; Carroll & Kincade, 2007; Chae & Evenson, 2014; Chang et al., 2009; Choi & Ashdown, 2002; Ilmarinen et al., 1990; LaBat et al., 2016; Michaelson, 2015; Tan et al., 1998). Pockets enable end-users to store tools, personal items, or other aids for their task (Black & Cloud, 2008; Choi & Ashdown, 2002; Ilmarinen et al., 1990). Hoods can help the end-user maintain body temperature, especially those undergoing medical treatment, or can protect the end-user from environmental hazards (Boorady et al., 2009; Choi & Ashdown, 2002; Kwok et al., 1997; Tremblay-Lutter et al., 1996). Gussets and articulated knees aid the end-user in mobility and are seen in sportswear and outdoor apparel (Anand, 2011; Bye & Hakala, 2005; Michaelson, 2015). Lastly, accessories and trims can aid in donning, doffing, and adjusting apparel by incorporating the use of elastic, tapes, cord, labels, visibility strips, and padding (Boorady, 2006, 2011; Boorady et al., 2009; Bye & Hakala, 2005;

Chan et al., 2015; Gupta, 2011a; McCann, 2016; Stokes & Black, 2012; Tan et al., 1998; Yick, Lai, Tsui, & Kwan, 2012).

Research question 3(h): What are wildland firefighters' perceptions of their NFPA 1977 Protective Clothing with respect to components?

Design: Closures

Closures aid the end-user in opening, closing, and adjusting apparel openings (Boorady, 2011; Pompelli, 1998; Watkins & Dunne, 2015). Closure considerations (e.g. button, zippers, snaps) for donning and doffing were found to impact individuals using hydrotherapy suits, competitive sailors, active aging community, medical conditions, and those with a disability (Bye & Hakala, 2005; Han et al., 2015; Kabel et al., 2016; Mahoney et al., 2015; McCann & Bryson, 2015; Na, 2007; Pompelli, 1998; Rusk & Taylor, 1959; Sau-Fun et al., 2011; Schulte, 2015; Wang et al., 2014). The dexterity of the end-user can affect the type of fasteners needed in the functional apparel, especially with wearing gloves (Han et al., 2015; McCann, 2016). Closures can encompass zippers, Velcro™, snaps, buttons, D-rings, and magnetics (Gupta, 2011a; Pompelli, 1998; Watkins & Dunne, 2015). The quality of these fasteners impacts the end-user if they are faulty, don't work properly, or fail to hold because this can place the end-user in a harmful situation (Havenith & Heus, 2004; Michaelson, 2015; Power et al., 2017).

Research question 3(i): What are wildland firefighters' perceptions of the closures in their NFPA 1977 Protective Clothing?

Production: Sizing System

Wildland firefighters' sizing system is regulated by the NFPA 1977 regulation (National Fire Protection Association, 2016). Communicating sizing starts with a sizing chart and label so that wildland firefighters can match their measurements to the sizing system (Brown & Rice, 2013;

National Fire Protection Association, 2016). A complication with sizing is that not all consumers know their measurements or how to accurately take body measurements, thereby making sizing mistakes during purchases (Chun, 2007; Song & Ashdown, 2013). Additional problems have been found when their body measurements fall into different sizes; thereby posing a challenge for the consumers to find the appropriate size when they fall into more than one size category (Song & Ashdown, 2013; Zakaria, 2016). NFPA 1977 manufacturers typically provide sizing charts to aid the wildland firefighters in choosing the correct size. Sizing charts have various measurements, depending on the apparel category, and may include measurements for chest, waist, sleeve length, inseam, front rise, neck, or other body measurement areas (see Figure 12) (Faust & Carrier, 2014; National Fire Fighter Corp., 2019). Ideally, any information about body measurements should include a picture with reference to the body area so the end-user can make an informed decision on where to take the measurement.

SHIRTS/COATS

	CrewBoss		True North		Coaxsher		Propper			Lakeland	
Size	Chest	Sleeve	Chest	Sleeve	Chest	Sleeve	Chest	Sleeve	Neck	Chest	Sleeve
Small	34-36"	32"	33-36"	32-3/4"	38-40"	32"	34-36"	33-33.5"	13-13.5"	36-38"	34"
Medium	38-40"	33"	37-40"	33-5/8"	40-44"	33"	38-40"	34-34.5"	14-14.5"	40-42"	35"
Large	42-44"	34"	41-44"	34"	44-48"	35"	42-44"	35-35.5"	15-15.5"	44-46"	36"
X-Large	46-48"	35"	45-48"	34-5/8"	48-52"	36"	46-48"	36-36.5"	16-16.5"	48-50"	37"
2X-Large	50-52"	36"	49-52"	35-1/4"	52-56"	37"	50-52"	37-37.5"	17-17.5"	52-54"	38"
3X-Large	54-56"	37"	53-56"	35-7/8"	56-60"	38"	54-56"	38-38.5"	18-18.5"	56-58"	39"
4X-Large					60-64"	39"				60-62"	40"
5X-Large										64-66"	41"
6X-Large										68-70"	42"

Figure 12. Wildland firefighting sizing chart for shirts and coats (National Fire Fighter Corp., 2019)

Research question 4(a): What are wildland firefighters' perceptions of the sizing system of their NFPA 1977 Protective Clothing?

Production: Quality

Quality in wildland firefighters NFPA 1977 protective apparel is governed by the National Fire Protection Association (National Fire Protection Association, 2016). Guidelines are in place to maintain a certain level of quality to protect the wildland firefighters when they are fighting fires. The testing of textiles, seams, and closures have strict requirements that must be used in order to manufacture wildland firefighting apparel under NFPA 1977 (National Fire Protection Association, 2016). Even with these regulations, the perception of quality can change over time due to wear and laundering of the protective apparel, so investigating quality should be done after wear and laundering (Brown & Rice, 2013; Bye & Hakala, 2005).

Research question 4(b): What are wildland firefighters' perceptions of their NFPA 1977 Protective Clothing with respect to quality?

Production: Ease of Care

Wildland firefighters have to care for the protective apparel, and this process can include odor and stain removal, environmental hazard removal, laundering procedures, and storage of the protective apparel (National Fire Protection Association, n.d.; Nayak & Padhye, 2015). Most wildland firefighters' protective apparel is made from Nomex®, and DuPont has created care guidelines to aid in the maintenance and longevity of their apparel (DuPont, 2018). Nomex® is a heat and flame-resistant textile made by DuPont, but it is not effective if it is excessively soiled or has punctures (DuPont, 2018). Wildland firefighters' apparel requires elevated temperature washing so any NFPA 1977 protective apparel must be able to withstand elevated temperatures in washing and drying while preserving the heat and flame-resistant properties (DuPont, 2018; National Fire Protection Association, 2016, n.d.). Consumers, in general, desire apparel that has easy care, resists shrinkage after washing, and is stain resistant (Abraham-Murali & Littrell, 1995; Feltham & Martin, 2006; Fowler, 1999; Lee et al., 2009; Mitchka et al., 2009; Nayak & Padhye, 2015; Shin, 2000; Wheat & Dickson, 1999). Overall, ease of care is a desired trait relevant to the needs of the wildland firefighter.

Research question 4(c): What are wildland firefighters' perceptions of their NFPA 1977 Protective Clothing based on ease of care?

Production: Availability

The availability of functional apparel can impact wildland firefighters when the proper size, length, and type of apparel is not available for them. This is especially true as NFPA 1977 protective apparel must be ordered by mail or online prior to being tried. Park et al. (2014) reported that firefighters had difficulty finding the correct size of turnout boots; the wrong size can cause issues in completing their tasks. Similar problems have been reported with the availability of sportswear in apparel lengths, such as pant, back, or sleeve lengths, and have been reported with ice hockey, rock climbing, sailing, golf, basketball, and tennis players (Boorady, 2006; Bye & Hakala, 2005; Chae & Evenson, 2014; Feather et al., 1996; Jin & Black, 2012; Michaelson, 2015; Wheat & Dickson, 1999). Manufacturers and employers of NFPA 1977 Protective Clothing need to realize the importance of their wildland firefighters' sizing and body shape, so that the correct size of apparel can be made available to them.

Research question 4(d): What are wildland firefighters' perceptions of their NFPA 1977 Protective Clothing with respect to availability?

CHAPTER 3. METHODOLOGY

Summary of Purpose

This study proposed a Multidimensional Functional Apparel Framework (MFAF), which was applied using two separate case studies that examined different ages, genders, and types of functional apparel categories, along with different theories, using a mixed methods approach. Overall, these case studies investigated to what extent the quantitative results agree with the qualitative findings for each of the Multidimensional Functional Apparel Framework variables tested in the separate studies and what additional variables, if any, emerged from the gathering of quantitative data and qualitative open-ended question data in each of the studies.

Research Design: Case Study 1 – Investigating Usage and Expectations of Sun Protective Apparel in Children

Sampling Procedures and Sample Characteristics

A purposive sample was used to recruit parents through Centiment, a survey panel recruitment firm, which was paid to recruit 160 participants based on the following criteria: a) participants being 19 years or older, b) having or caring for a child under 19 years of age who plays or swims in the water, and c) residing in the United States. No preference for gender was required for the survey. Centiment was given collaboration rights on Qualtrics software for this study's survey so they could distribute it, but the researchers maintained control and access to the survey and the results. Data collection was completed through Qualtrics as an online survey.

Participants were a parent or caregiver, over the age of 19, and had at least one child, under the age of 19, and who swims or plays in the water. After obtaining Auburn University Institutional Review Board (IRB) approval, recruiting commenced. A minimum sample size of 160 participants was needed to avoid any power issues. The online questionnaire contained an

IRB approved Information Letter that discussed the purpose of the study, potential risks and discomforts, benefits, compensation, confidentiality, voluntary participation and withdrawal, consent, and contact information for the study.

Potential participants were told that the research was investigating usage and satisfaction with children's sun-protective clothing, parental intentions to use sun protection on their child(ren), the types of sun protection used, and the perceived deterrents for using of sun protective clothing. Potential participants were asked if they would be willing to participate in the research study. If interested, they were able to proceed with the online questionnaire.

Instrumentation

The questionnaire, shown in Appendix C, was developed based on published apparel assessment and sun protection studies, along with the variables proposed in the Multidimensional Functional Apparel Framework, with a minimum reported scale reliability of Cronbach's *alpha* coefficient of .63 based on the original study or from other studies using the scale (Armitage & Conner, 1999; Glanz et al., 2008; LaBat & DeLong, 1990; Mermelstein & Riesenberg, 1992; Reed, Jones, Walker, & Hoover-Dempsey, 2000; Simon, 1992; Thomson, White, & Hamilton, 2012). The instrument was an online survey displaying the Auburn University and Department of Consumer and Design Sciences logo with the title of the research study. The following measures were included in the survey.

End-User: Skin type. To determine the skin type of the child, a table was provided so the participant could read the skin type descriptions as it applies to sunburn. This table was published by Healthwise.org (2017) and includes the skin type number, race/ethnicity descriptors, and sunburn descriptions (see Figure 13). The table was modified to remove the race/ethnicity to avoid sterotyping by race or ethniticity along with potential confusion with mixed races (see Figure 14).

Skin types and sunburn

Type I	Red hair, freckles (extremely sensitive)	You sunburn easily and are not likely to tan.
Type II	Fair skin, blue eyes (very sensitive)	You usually sunburn easily and tan a little.
Type III	Most whites (sensitive)	You sunburn sometimes and tan slowly.
Type IV	Mediterranean, Hispanic, Asian (moderately sensitive)	You sunburn a little and usually tan well.
Type V	Middle Eastern, Latino, Indian, light-skinned blacks (minimally sensitive)	You rarely sunburn, and you tan deeply.
Type VI	Dark-skinned blacks (not sensitive)	You almost never sunburn.

Figure 13. Skin type and sunburn (Healthwise.com, 2017)

What **skin type** is this child? (Circle one)

I	Sunburn easily and are not likely to tan.
II	Usually sunburn easily and tan a little.
III	Sunburn sometimes and tan slowly.
IV	Sunburn a little and usually tan well.
V	Rarely sunburn, and tan deeply.
VI	Almost never sunburn.

Figure 14. Child's skin type

End-User: Perceived sun protective apparel deterrents. To investigate any perceived sun protective apparel deterrents, the study asked one categorical question with a follow up open-ended question. This question asked does your child own (or has ever owned) sun protective apparel to swim or play in the water with a yes or no response. It was followed with the statement, "If yes, proceed to the next question" and "If no, what are the reasons for not using or purchasing children's sun protective apparel? List all the reasons below" (see Figure 15).

Does your child own (or has ever owned) sun protective apparel?

YES	NO

- If YES, proceed to the next question.
- If NO, what are the reasons for not using or purchasing children's sun protective apparel? List all the reasons below.

Figure 15. Perceived sun protective apparel deterrent questions

Task: Compliance. Questions on compliance were based on the Intentions scale with a 7-point agree scale (1= definitely do not, to 7= definitely do), which reported a Cronbach *alpha* of .86 (Armitage & Conner, 1999). The questions were modified (shown in italics) to ask (a) I intend to ensure *my child wears sun protection apparel,* (b) I plan to ensure *my child wears sun protection apparel*, and (c) I want to ensure *my child wears sun protection apparel* (see Figure 16).

I intend to ensure my child wears sun protective apparel.

Strongly Disagree	1 ...2 ...3 ...4 ...5 ...6 ...7	Strongly Agree

I plan to ensure my child wears sun protective apparel.

Strongly Disagree	1 ...2 ...3 ...4 ...5 ...6 ...7	Strongly Agree

I want to ensure my child wears sun protective apparel.

Strongly Disagree	1 ...2 ...3 ...4 ...5 ...6 ...7	Strongly Agree

Figure 16. Compliance questions

Design: Comfort. The question on the child's comfort in sun protective apparel stated "My child's sun protective apparel is comfortable" with a 7-point agree scale (1=strongly disagree, to 7=strongly agree) (see Figure 17).

My child's sun protective apparel is **comfortable**.

Strongly Disagree	1 ...2 ...3 ...4 ...5 ...6 ...7	Strongly Agree

My child is able to **move properly** in sun protective apparel.

Strongly Disagree	1 ...2 ...3 ...4 ...5 ...6 ...7	Strongly Agree

Figure 17. Comfort and mobility questions

Design: Mobility. The question on mobility of their child's sun protective apparel stated "My child's is able to move properly in sun protective apparel" with a 7-point agree scale (1=strongly disagree, to 7=strongly agree) (see Figure 18).

My child is able to **move properly** in sun protective apparel.

Strongly Disagree	1 ...2 ...3 ...4 ...5 ...6 ...7	Strongly Agree

Figure 18. Mobility question

Design: Body shape. The question about the body shape being compatible with the child's sun protective apparel stated "My child's sun protective apparel is good for my child's body shape" with a 7-point agree scale (1=strongly disagree, to 7=strongly agree) (see Figure 19).

My child's sun protective apparel is good for my child's **body shape**.

Strongly Disagree	1 ...2 ...3 ...4 ...5 ...6 ...7	Strongly Agree

The **sizing** of sun protective apparel is accurate.

Strongly Disagree	1 ...2 ...3 ...4 ...5 ...6 ...7	Strongly Agree

Figure 19. Body shape and sizing questions

Production: Sizing system. The question about the sizing system being accurate stated "The sizing of sun protective apparel is accurate" with a 7-point agree scale (1=strongly disagree, to 7=strongly agree) (see Figure 19).

Task: Protection. The question on the sun protective effectiveness of their child's sun protective apparel stated "The sun protective apparel protected my child from the sun" with a 7-point agree scale (1=strongly disagree, to 7=strongly agree) (see Figure 20).

Design: Durability. The question about the durability of their child's sun protective apparel stated "My child's sun protective apparel is durable" with a 7-point agree scale (1=strongly disagree, to 7=strongly agree) (see Figure 20).

Design: Ease of don and doff. The question on the ease of putting on and removing their child's sun protective apparel stated "My child can easily put on their sun protective apparel" followed by "My child can easily remove their sun protective apparel" with a 7-point agree scale (1=strongly disagree, to 7=strongly agree) (see Figure 20).

The sun protective apparel **protected** my child from sun.

Strongly Disagree	1 ...2 ...3 ...4 ...5 ...6 ...7	Strongly Agree

My child's sun protective apparel is **durable**.

Strongly Disagree	1 ...2 ...3 ...4 ...5 ...6 ...7	Strongly Agree

My child or myself can **easily put on** sun protective apparel.

Strongly Disagree	1 ...2 ...3 ...4 ...5 ...6 ...7	Strongly Agree

My child or myself can **easily remove** their sun protective apparel.

Strongly Disagree	1 ...2 ...3 ...4 ...5 ...6 ...7	Strongly Agree

Figure 20. Protection, durability and don/doff questions

Design: Fit. Questions on fit were based on LaBat and DeLong (1990) Fit Satisfaction Scale that has twenty body areas (see Figure 21), which were originally rated on a 5-point scale

Site
Pant length
Crotch
Thigh
Buttocks
Hip
Sleeve length
Waist length
Waist
Abdomen
Shoulder blade
Bust
Shoulder
Skirt length
Armscye
Upper arm
Midriff
Calf
Lower arm
Elbow
Neckline

Figure 21. Fit Satisfaction Scale (LaBat & DeLong, 1990).

(1=lowest satisfaction, to 5=highest satisfaction). This study question asked about the fit satisfaction for the child's sun protective apparel and was modified to use a 7-point satisfaction scale (1=Dissatisfied, to 7=Satisfied) along with the addition of a "not applicable" area. The body fit areas included sixteen areas that relate a to child's sun apparel (see Figure 22). One body area, short length, was added as many children's swim apparel comes in shorts; calf, midriff, and hip were deleted as these are from the original LaBat and DeLong (1990) Fit Satisfaction Scale not commonly referred to areas in children's apparel.

Indicate your **fit satisfaction** with your child's sun protective apparel for each of the following body areas:

Neckline	Dissat-isfied	1 ..2 ..3 ..4 ..5 ..6 ..7	Satis-fied	n/a
Sleeve Length	Dissat-isfied	1 ..2 ..3 ..4 ..5 ..6 ..7	Satis-fied	n/a
Waist Length	Dissat-isfied	1 ..2 ..3 ..4 ..5 ..6 ..7	Satis-fied	n/a
Waist	Dissat-isfied	1 ..2 ..3 ..4 ..5 ..6 ..7	Satis-fied	n/a
Abdo-men	Dissat-isfied	1 ..2 ..3 ..4 ..5 ..6 ..7	Satis-fied	n/a
Shoul-der	Dissat-isfied	1 ..2 ..3 ..4 ..5 ..6 ..7	Satis-fied	n/a
Armhole	Dissat-isfied	1 ..2 ..3 ..4 ..5 ..6 ..7	Satis-fied	n/a
Upper arm	Dissat-isfied	1 ..2 ..3 ..4 ..5 ..6 ..7	Satis-fied	n/a
Lower arm	Dissat-isfied	1 ..2 ..3 ..4 ..5 ..6 ..7	Satis-fied	n/a
Elbow	Dissat-isfied	1 ..2 ..3 ..4 ..5 ..6 ..7	Satis-fied	n/a
Pant Length	Dissat-isfied	1 ..2 ..3 ..4 ..5 ..6 ..7	Satis-fied	n/a
Short Length	Dissat-isfied	1 ..2 ..3 ..4 ..5 ..6 ..7	Satis-fied	n/a
Skirt Length	Dissat-isfied	1 ..2 ..3 ..4 ..5 ..6 ..7	Satis-fied	n/a
Crotch	Dissat-isfied	1 ..2 ..3 ..4 ..5 ..6 ..7	Satis-fied	n/a
Thigh	Dissat-isfied	1 ..2 ..3 ..4 ..5 ..6 ..7	Satis-fied	n/a
Buttock	Dissat-isfied	1 ..2 ..3 ..4 ..5 ..6 ..7	Satis-fied	n/a

Figure 22. Fit scale

Task: Textiles and fasteners. The question on satisifaction with textiles and fasteners used in child's sun protective apparel asked "How satisfied are you with the fabrics and fasteners on your child's sun protective apparel" on a 7-point satisfied scale (1=strongly dissatisfied, to 7=strongly satisfied) (see Figure 23).

I am satisfied with the **fabrics and fasteners** in my child's sun protective apparel.

Strongly Dissatisfied	1 ...2 ...3 ...4 ...5 ...6 ...7	Strongly Satisfied

I am satisfied with the **construction** of my child's sun protective apparel.

Strongly Dissatisfied	1 ...2 ...3 ...4 ...5 ...6 ...7	Strongly Satisfied

Figure 23. Textiles, fasteners, and construction questions

Production: Construction. The question on the construction of child's sun protective apparel asked "How satisfied are you with the construction of your child's sun protective apparel on a 7-point satisfied scale (1=strongly dissatisfied, to 7=strongly satisfied) (see Figure 23).

Production: Quality. The question on the quality of their child's sun protective apparel asked "How satisfied are you with the quality of your child's sun protective apparel" on a 7-point satisfied scale (1=strongly dissatisfied, to 7=strongly satisfied) (see Figure 24).

I am satisfied with the **quality** of my child's sun protective apparel.

Strongly Dissatisfied	1 ...2 ...3 ...4 ...5 ...6 ...7	Strongly Satisfied

I am satisfied with the **ease of care** of my child's sun protective apparel.

Strongly Dissatisfied	1 ...2 ...3 ...4 ...5 ...6 ...7	Strongly Satisfied

I feel sun protective apparel is **affordable**.

Strongly Disagree	1 ...2 ...3 ...4 ...5 ...6 ...7	Strongly Agree

I am satisfied with the **availability** of sun protective apparel in stores.

Strongly Disagree	1 ...2 ...3 ...4 ...5 ...6 ...7	Strongly Agree

Figure 24. Quality, ease of care, affordability, and availability questions

Production: Ease of care. The question on the ease of care asked “How satisfied are you with the ease of care in your child’s sun protective apparel” on a 7-point satisfied scale (1=strongly dissatisfied, to 7=strongly satisfied) (see Figure 24).

End-User: Affordability. The question on the affordabity of child’s sun protective apparel asked “I feel my child’s sun protective apparel is aforable” on a 7-point satisfied scale (1=strongly dissatisfied, to 7=strongly satisfied) (see Figure 24).

Production: Availability. The question on the availability of child’s sun protective apparel asked “How satisfied are you with the availability of sun protective apparel in sotres” on a 7-point satisfied scale (1=strongly dissatisfied, to 7=strongly satisfied) (see Figure 24).

End-User: Styles. To investigate what syles of child’s sun protective apparel the child prefers, the following open-ended question asked “What styles of sun protecive apparel does you child prefer to wear outside in the water? List all the reasons below.” It was accompanied with a text box for the participant to write his/her response (see Figure 25).

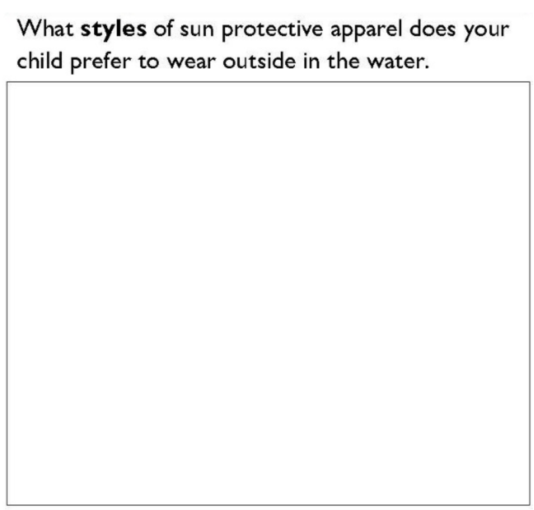


Figure 25. Styles question

Other reasons. To investigate if there were any other reasons why a participant might not be satified with sun protective apparel, the researcher asked an open-ended question, “Are there any other reasons why sun protective apparel does not fully satisfy you or your child's needs? List all the reasons below" (see Figure 26).

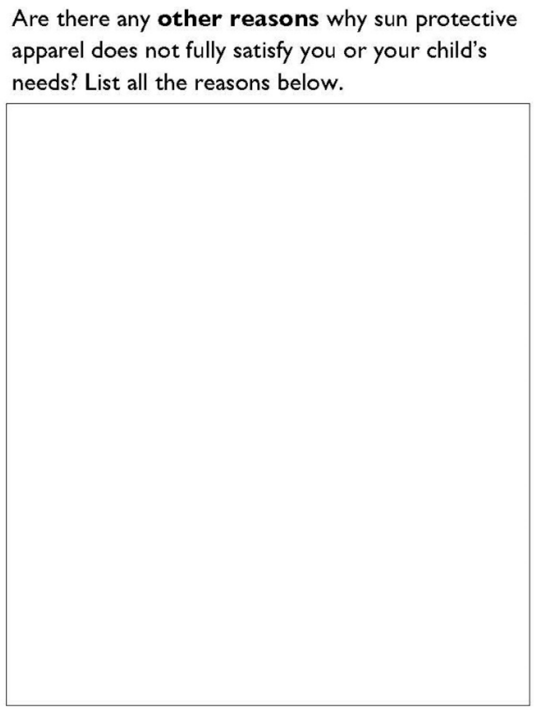
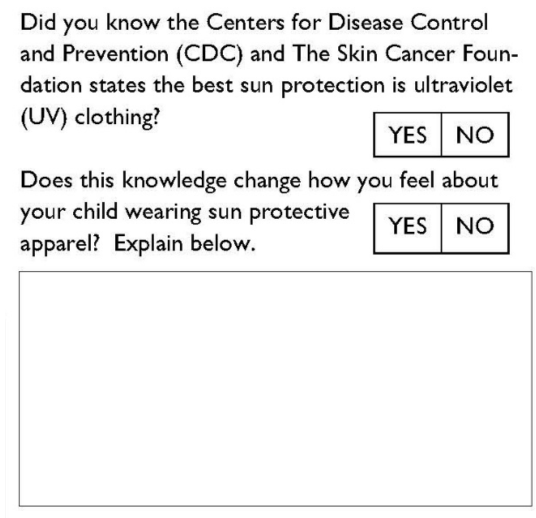

Are there any **other reasons** why sun protective apparel does not fully satisfy you or your child's needs? List all the reasons below.

Figure 26. Other reasons question

End-User: Knowledge of current sun protection guidelines. The researcher wanted to know the participants' knowledge of current sun protection guidelines; so they asked the participants two categorical questions with a follow up open-ended question for each. The first question asked "Did you know the Centers for Disease Control (CDC) and The Skin Cancer Foundation states the best sun protection is ultraviolet (UV) clothing?" with a yes or no response. It was followed with the question, "Does this knowledge change how you feel about your child wearing sun protective apparel? Explain below." with a yes or no response box and a text box so participants could write an explanation (see Figure 27).


Did you know the Centers for Disease Control and Prevention (CDC) and The Skin Cancer Foundation states the best sun protection is ultraviolet (UV) clothing?

YES	NO

Does this knowledge change how you feel about your child wearing sun protective apparel? Explain below.

YES	NO

Figure 27. Knowledge of current sun protection guidelines question

Demographics. The demographic section of the questionnaire asked the participant's relationship to the child (parent, family member, caregiver, other), the child's age, the participant's age, the number of children under 18 living with the participant, gender, marital status, state of residence, education level, and ethnicity.

Face Validity. Pilot testing was conducted with two parents with children, along with a professor, to improve the clarity of questions and the formatting of the questionnaire prior to the main study. Feedback from the pilot testing was reviewed by the researchers and it was found that only minor sentence structure needed to be corrected on three questions to provide better clarification. This pilot test established face validity of the questionnaire.

Data Collection Procedures. A contract with Centiment was implemented by the researchers. Once the contract was received, Centiment distributed the questionnaire through its offices. Participants were able to exit the questionnaire at any time by closing their browser window. Data collection started within one day of the signed contract and a pilot was run with a dozen participants so that the researcher could confirm the quality of the participant responses. After confirmation, the remaining participants were acquired in three (3) business days. After the minimum number of participants were collected, the researchers paid Centiment based on the signed contract. The online questionnaire was then closed in Qualtrics.

Data Analysis. Questionnaire data were downloaded from Qualtrics in SPSS format and imported into SPSS version 24.0 statistical software. Prior to analysis, the data were cleaned, and all errors or anomalies were identified and corrected. Descriptive statistics were used to analyze the sample characteristics and scale responses. A table showing each item along with the mean, frequency, and percentages was developed. Scale reliability was analyzed using Cronbach's *alpha* coefficient for each of the measures with more than one item.

Open-ended questions were analyzed using a content analysis approach. The questionnaire responses were placed into an Excel spreadsheet for analysis. A coding scheme for each research question were generated based on the meaningful segments of the responses. These segments were then organized into themes. The researchers condensed the themes for each open-ended question. A coding guide for each question was then developed to include codes, names, definitions, and example comments for each theme. Two coders, along with a third for mediation, coded all the open-ended questions. Once all data had been coded, it was imported back into SPSS for analysis. Each of the coders were assigned a categorical variable and then a corresponding numerical value for each theme name based on the coding guides. Inter-coder reliability analysis was done with the Kappa statistic in SPSS to determine the consistency between coders for each open-ended question, and then reported in a table. The coded results were cross-tabulated in SPSS to compare the two coders' results, which revealed the most frequently repeated themes. Results were reported by theme, frequency, and typical comments for each open-ended research question.

The following hypotheses and research questions were analyzed in case study 1:

Research Question 1: What perceived deterrents, if any, do parents have for using sun protective clothing on their child(ren)? This open-ended question, "What are the reasons for not using or purchasing children's sun protective apparel? List all the reasons below." This question was analyzed using a content analysis approach that grouped the participant responses based on a common theme. Descriptive statistics were used to report the perceived deterrents-based frequency and percentage of themes mentioned in the responses.

Research Question 2: What are the parental preferences for sun protective apparel styles in children? This was an open-ended question and was analyzed with a content analysis approach by grouping participant responses based on a common theme. Descriptive statistics were used to report the styles of sun protective apparel preferred by parents based on a theme by frequency and percentage.

Research Question 3: At what level are children's sun protective apparel fulfilling the parent's expectations for the *end-user dimension* of the Multidimensional Functional Apparel Framework (MFAF): affordability?

Affordability was a single question with a 7-point agree scale (1=Strongly disagree, 2=Disagree, 3=Somewhat disagree, 4=Neither agree nor disagree, 5=Somewhat agree, 6=Agree, and 7=Strongly agree). Descriptive statistics were used to report the mean for each variable.

Research Question 4: At what level are children's sun protective apparel fulfilling the parent's expectations for the *task dimension* of the Multidimensional Functional Apparel Framework (MFAF): (a) protection from the sun, (b) compliance, and (c) textiles?

(a) Protection from the sun. This variable was a single question with a 7-point agree scale (1=Strongly disagree, 2=Disagree, 3=Somewhat disagree, 4=Neither agree nor disagree, 5=Somewhat agree, 6=Agree, and 7=Strongly agree). Descriptive statistics were used to report the mean for each variable.

(b) Compliance. A mean composite measure was created for compliance based on a 7-point agree scale (1=Strongly disagree, 2=Disagree, 3=Somewhat disagree, 4=Neither agree nor disagree, 5=Somewhat agree, 6=Agree, and 7=Strongly agree). Descriptive statistics were used to report the compliance of the participants.

(b) Textiles. This variable was a single question asking about satisfaction with fabrics and fasteners, with a 7-point agree scale (1=Strongly disagree, 2=Disagree, 3=Somewhat disagree, 4=Neither agree nor disagree, 5=Somewhat agree, 6=Agree, and 7=Strongly agree). Descriptive statistics were used to report the mean for each variable.

Research Question 5: At what level are children's sun protective apparel fulfilling the parent's expectations for the *design dimension* of the Multidimensional Functional Apparel Framework (MFAF): (a) fit, (b) body shape, (c) mobility, (d) durability, (e) comfort, and (f) donning and doffing ease.

(a) Fit. Repeated-measures ANOVA with 16 levels (body areas) were used to assess fit satisfaction related to sun protection by comparing the means of the 16 fit body areas. If the ANOVA revealed a significant difference, a Tukey's HSD post hoc analysis was performed to determine which pairwise comparison was significantly different. This variable was rated on a 7-point satisfaction scale (1=Extremely dissatisfied, 2=Moderately dissatisfied, 3=Slightly dissatisfied, 4=Neither satisfied nor dissatisfied, 5=Slightly satisfied, 6=Moderately satisfied, 7=Extremely satisfied) along with a not applicable field. The not applicable field allowed for this level (body area) to not be calculated in analyses.

(b) Body shape, (c) mobility, (d) durability, (e) comfort, and (f) donning and doffing ease. Each variable was a single question with a 7-point agree scale (1=Strongly disagree, 2=Disagree, 3=Somewhat disagree, 4=Neither agree nor disagree, 5=Somewhat agree, 6=Agree, and 7=Strongly agree). Descriptive statistics were used to report the mean for each variable.

Research Question 6: At what level are children's sun protective apparel fulfilling the parent's expectations for the *production dimension* of the Multidimensional Functional Apparel Framework: (a) sizing system, (b) construction, (c) quality, (d) ease of care, and (e) availability. Each variable was a single question with a 7-point agree scale (1=Strongly disagree, 2=Disagree, 3=Somewhat disagree, 4=Neither agree nor disagree, 5=Somewhat agree, 6=Agree, and 7=Strongly agree). Descriptive statistics were used to report the mean for each variable.

Research Design: Case Study 2 – Wildland Firefighters' Perceptions of NFPA 1977 Protective Apparel

Sampling Procedures and Sample Characteristics

A purposive sample was used to recruit wildland firefighters during Summer and Fall, 2018. Wildland firefighters must have been over the age of 19 and have worn NFRP 1977 Protective Clothing. After obtaining Auburn University Institutional Review Board (IRB) approval, recruiting commenced through various wildland firefighting companies and the US Forest Service Apprenticeship Program. A minimum sample size of 50 participants was needed to avoid any power issues. Wildland firefighters were recruited from all areas of the United States with no preference in geographic location. An online anonymous Qualtrics questionnaire was developed for distribution through a hyperlink address. The hyperlink to the questionnaire along with a research summary was provided to the participating companies so that it could be sent directly to employees by their employers. The online questionnaire contained an IRB approved Information letter that discussed the purpose of the study, potential risks and discomforts, benefits, compensation, confidentiality, voluntary participation and withdrawal, consent, incentives, and contact information for the study.

At the end of the questionnaire, participants were directed to the Rafflecopter website for a chance to win one of two $50 Amazon e-gift cards, 1/25 chance of winning. The researcher used a separate website for accumulation of participant's email addresses, so they could not be linked to the questionnaire and official reporting of winners could be made while keeping all participants information confidential. The incentive was set-up through the researcher's account on www.rafflecopter.com. The site notified the researcher by email when there was a winner and the e-gift card was sent to the winner. There was no gender preference for the study, but participants had to be at least 19 years of age and have worn NFRP 1977 Protective Clothing within the last 12 months. The timeline for data collection was approximately 12 weeks due to the wildland firefighters' unpredictable schedules during fire season and started within one week of IRB approval. The following companies provided permission letters for this study:

- Red Truck Wildfire, LLC, PO Box 191073, Boise, Idaho 83719 (208) 869-5258, approximately 30 to 50 employees
- PatRick Environmental, Inc., PO Box 758, Redmond, Oregon 97756 (541) 923-0703, between 200 to 350 employees
- US Forest Service, Wildland Firefighter Apprenticeship Program, 3833 S. Development Avenue, Boise, Idaho 83705 (916) 202-6850, over 2,000 trained apprentices and approximately 48 new apprentices trained at Auburn University's Dixon Solon Dixon Forestry Education Center with its first academy in March 2018.

Instrumentation

The questionnaire for study 2, shown in Appendix D, was developed based on published apparel assessment studies, along the variables proposed in the Multidimensional Functional Apparel Framework with a minimum reported scale reliability of Cronbach's *alpha* coefficient of .70 based on the original study or from other studies using the scale (Barker & Black, 2009; Fowler, 1999; Huck et al., 1997; LaBat & DeLong, 1990; Rutherford-Black & Khan, 1995; U.S. Navy Clothing and Textile Research Facility, 1998).

End-User: Affordability. The affordability question used a 7-point semantic differential scale (1 = Not affordable; 7 = Very affordable) and asked participants to rate how affordable they felt their firefighting apparel was (see Figure 28).

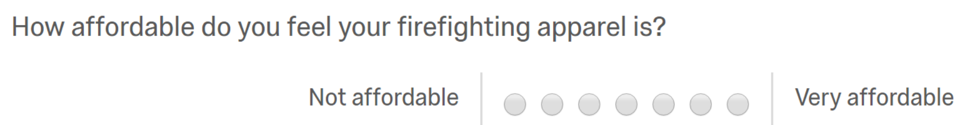
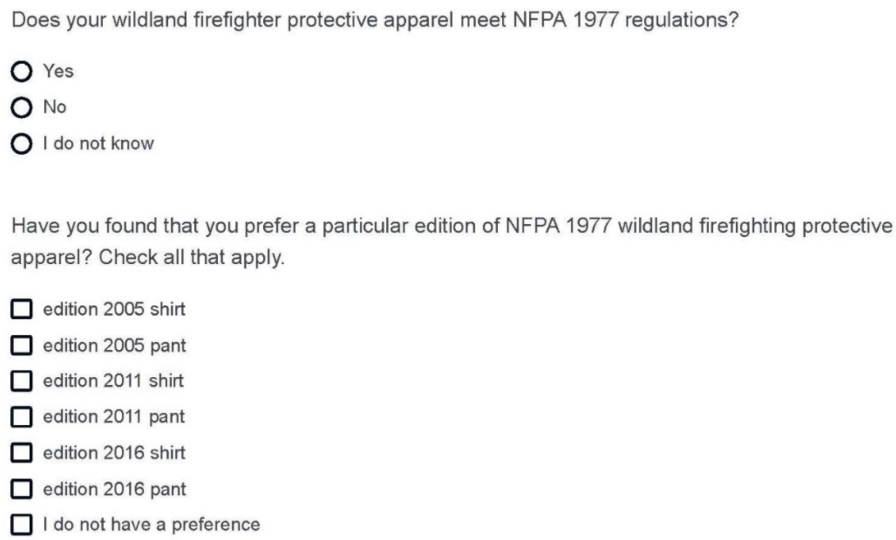


Figure 28. Wildland firefighters' apparel affordability questions

Task: Protection. To investigate if participants had experienced any protective problems with their protective apparel, the researcher asked participants an open-ended question. The open-ended question requested: (a) list any pant areas that you do not feel provide adequate protection, please explain, and (b) list any shirt areas that you do not feel provide adequate protection, please explain. A multiline text box was also provided below the question for the participant to use.

Task: NFRP 1977 regulations. This section has two questions. The first question asked if the participant's wildland firefighter protective apparel met NFPA 1977 regulations with response options of yes, no, or I do not know (see Figure 29). The next question asked if they preferred a particular edition of NFPA 1977 wildland firefighting protective apparel; it had the multiple response options of (a) edition 2005 shirt, (b) edition 2005 pant, (c) edition 2011 shirt, (d) edition 2011 pant, (e) edition 2016 shirt, (f) edition 2016 pant, and (g) no preference. Since these questions were categorical, scale reliability was not reported.


Does your wildland firefighter protective apparel meet NFPA 1977 regulations?

- Yes
- No
- I do not know

Have you found that you prefer a particular edition of NFPA 1977 wildland firefighting protective apparel? Check all that apply.

- edition 2005 shirt
- edition 2005 pant
- edition 2011 shirt
- edition 2011 pant
- edition 2016 shirt
- edition 2016 pant
- I do not have a preference

Figure 29. NFPA 1977 regulation questions for wildland firefighting apparel

Task: Equipment interaction. To investigate if participants had experienced any equipment interaction problems with their wildland firefighter apparel, the researcher asked participants an open-ended question. The open-ended question asked “Have you ever experienced any problems with your equipment causing problems with your movement, comfort, protection, fit, durability, or so on while working in your firefighting apparel? If so, please explain in detail what problems and equipment caused this. (If you have not experienced problems you can skip this question.)”. A multiline text box is provided below the question for the participant to use.

Design: Fit. The fit question was based on LaBat and DeLong (1990) Fit Satisfaction Scale (see Figure 30), which was modified to ask about the participants’ satisfaction with different areas of the (a) pant and (b) shirt using the NFPA 1977, edition 2016, pant and shirt

Site
Pant length
Crotch
Thigh
Buttocks
Hip
Sleeve length
Waist length
Waist
Abdomen
Shoulder blade
Bust
Shoulder
Skirt length
Armscye
Upper arm
Midriff
Calf
Lower arm
Elbow
Neckline

Figure 30. Fit Satisfaction Scale (LaBat & DeLong, 1990)

illustrations (National Fire Protection Association, 2016). The National Fire Protection Association (2016) illustrations are technical flats that show the pant front and back and the shirt back with a list of areas identified by a letter and arrows at the specific area denoted (see Figure 31). The researcher used these illustrations in the questionnaire to help participants understand the areas they needed respond to as some terms might not be common knowledge for all participants. Additionally, these were the same areas referenced for manufacturing sizing and fit standards for wildland firefighting protective apparel (National Fire Protection Association, 2016).

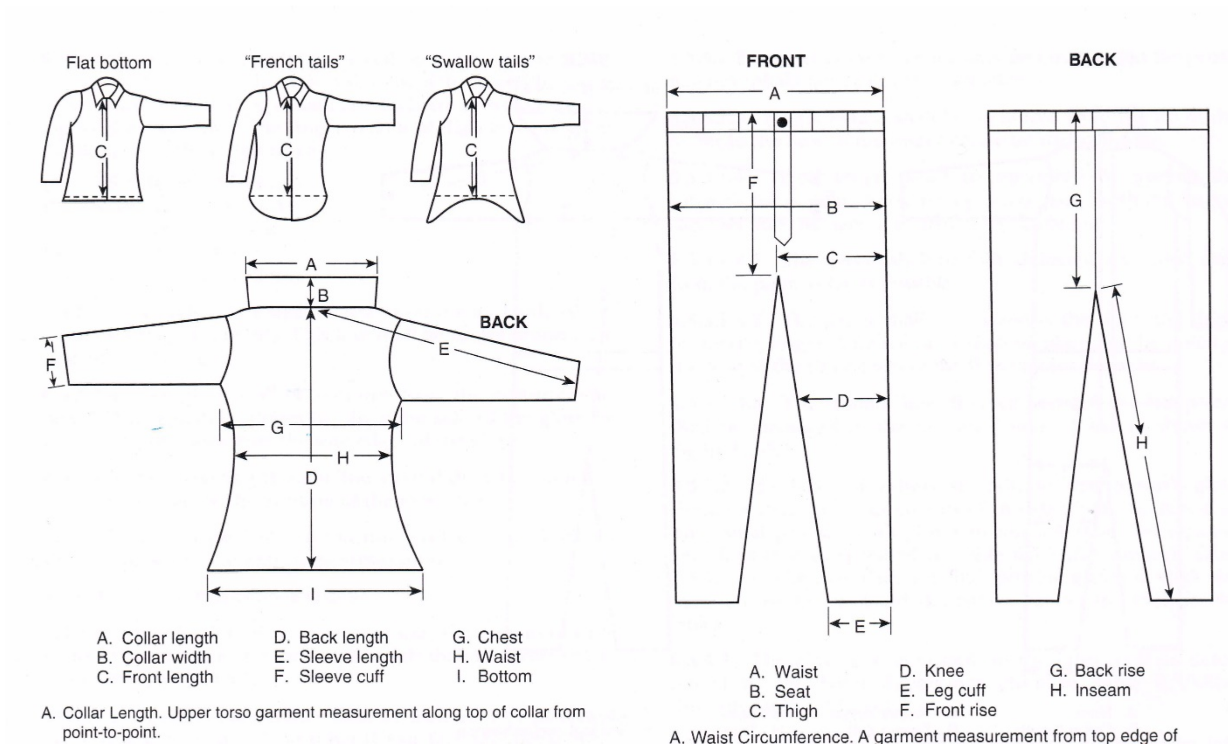
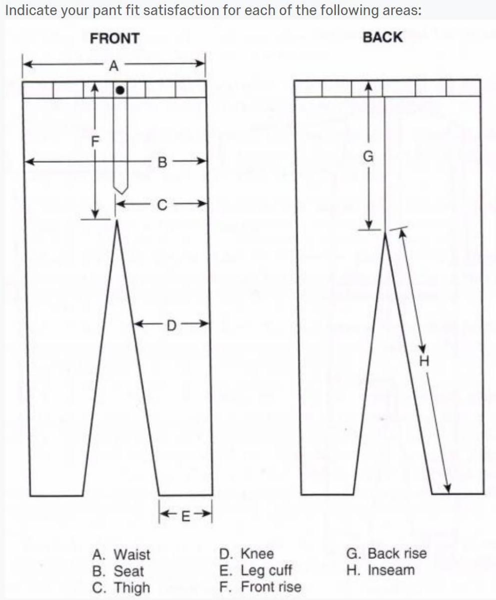


Figure 31. Wildland firefighter protective clothing illustrations (National Fire Protection Association, 2016)

The fit question was modified from LaBat and DeLong’s (1990) 5-point scale (1 = lowest satisfaction to 5 = highest satisfaction) to a 7-point satisfaction scale (1 = Stongly satisfied; 7 = Strongly dissatisfied) and included a not applicable field. Participants were instructed to indicate their fit satisfaction for each area. The pant had eight fit areas: (a) waist, (b) seat, (c) thigh, (d) knee, (e) leg cuff, (f) front rise, (g) back rise, and (h) inseam; the shirt had nine fit areas: (a) collar length, (b) collar width, (c) front length, (d) back length, (e) sleeve length, (f) sleeve cuff, (g) chest, (h) waist, and (i) bottom (see Figures 32 and 33). This was followed by an open-ended question asking the participant to explain any pant fit changes they had experienced.

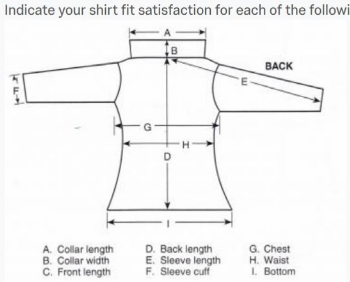
Indicate your pant fit satisfaction for each of the following areas:



	Extremely satisfied	Moderately satisfied	Slightly satisfied	Neutral	Slightly dissatisfied	Moderately dissatisfied	Extremely dissatisfied	× Not applicable
A. Waist								
B. Seat								
C. Thigh								
D. Knee								
E. Leg Cuff								
F. Front Rise								
G. Back Rise								
H. Inseam								

Figure 32. Fit satisfaction of NFPA 1977 wildland firefighter's pant

Indicate your shirt fit satisfaction for each of the following areas:



	Extremely satisfied	Moderately satisfied	Slightly satisfied	Neutral	Slightly dissatisfied	Moderately dissatisfied	Extremely dissatisfied	× Not applicable
A. Collar length								
B. Collar width								
C. Front length								
D. Back length								
E. Sleeve length								
F. Sleeve cuff								
G. Chest								
H. Waist								
I. Bottom								

Figure 33. Fit satisfaction of NFPA 1977 wildland firefighter's shirt

Design: Body shape. The question on body shape investigated the self-perceived body shape of wildland firefighters based on gender body shapes (see Figure 34). Participants were asked to indicate their gender and then were forwarded to the corresponding body shape scale by gender. The body shape scale had nine images for each gender, male and female, starting at a thin image to an obese image (Stunkard et al., 1983). The researcher used Qualtrics hot spot tool to assign predefined areas for each body shape, so that the participant could select his/her perceived body shape based on gender.

Figure 34. Wildland firefighters' perceived body shape based on gender question

Design: Mobility. To investigate if there were any mobility problems with wildland firefighters' protective apparel, the researcher asked the participants to select the apparel area(s) which caused problems while working (see Figure 35). The same National Fire Protection Association (2016) pant and shirt illustrations used in the fit satisfaction question were used to maintain consistency. The Qualtrics hot spot tool was used to assign predefined areas that could be selected by the participant and corresponded with garment areas, such as waist, thigh, inseam, sleeve length, and chest.

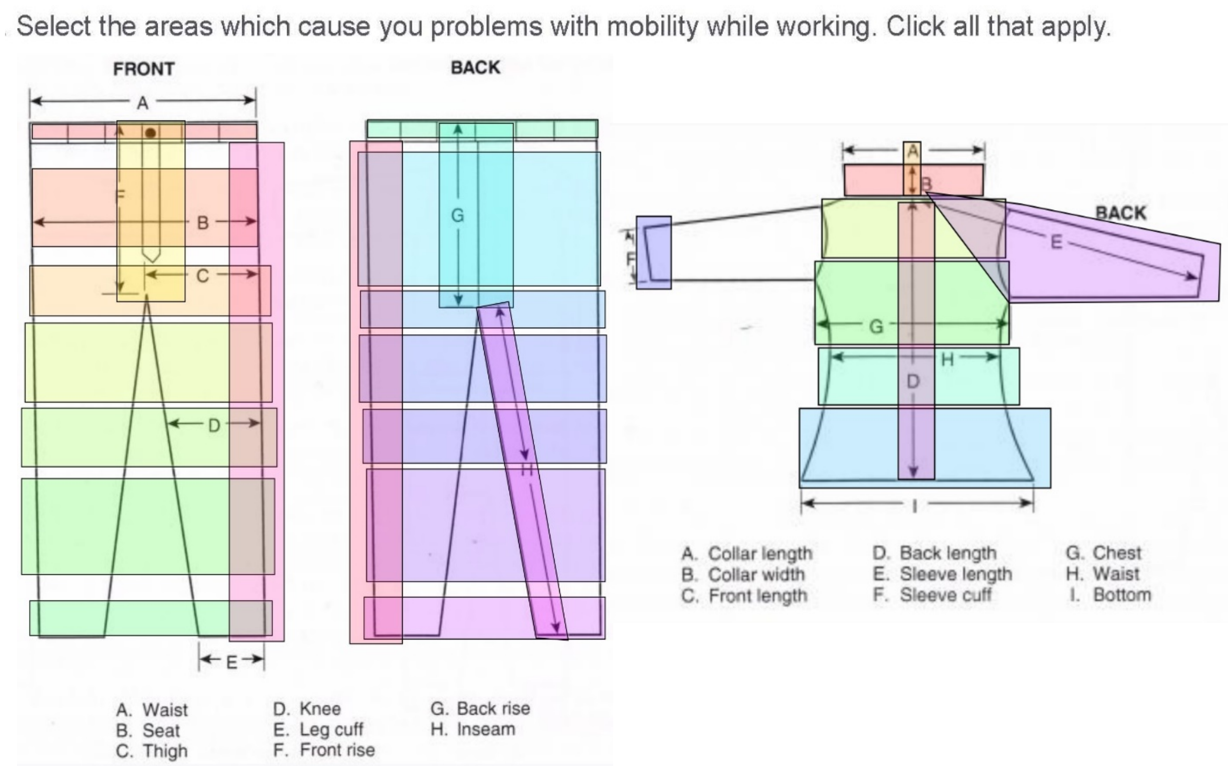


Figure 35. Mobility problem areas in wildland firefighters apparel (National Fire Protection Association, 2016)

Design: Durability. The durability rating of wildland firefighters' apparel, including areas on the garment along with seams, closures, and design detail, was done with three questions. The first was a durable/not durable 7-point semantic differential scale (see Figure 36), for the pant and shirt. This was followed by a question based on the U.S. Navy Wear Test and

q13. For the following garments please indicate all areas that have any durability problems.

Shirt	Arms	Back	Chest	Collar	Front	Cuff	Pockets	Seams	Buttons
57a. A (Poplin)	○1	○2	○3	○4	○5	○6	○7	○8	○9
57b. B (Chambray)	○1	○2	○3	○4	○5	○6	○7	○8	○9

Pant	Legs	Knee	Front	Seat	Waist	Pockets	Seams	Zippers	Buttons/ Snaps	Crotch
58a. A (Twill)	○1	○2	○3	○4	○5	○6	○7	○8	○9	○10
58b. B (Denim)	○1	○2	○3	○4	○5	○6	○7	○8	○9	○10

Figure 36. U.S. Navy wear test and user evaluation of enlisted utility uniforms: Durability q13 (Navy Clothing and Textile Research Facility, 1998)

User Evaluation of Enlisted Utility Uniforms: Durability q13, which asked the participant to select all areas that had durability problems on the pant; (a) legs, (b) knee, (c) front, (d) seat, (e) waist, (f) ankle, (g) crotch, (h) pockets, (i) seams, (j) buttons or snaps, and (k) zippers (see Figure 43) (U.S. Navy Clothing and Textile Research Facility, 1998). Question 11a was modified to add Velcro™, elastic, and buckle options as they are common on wildland firefighter's apparel (see Figure 37). The next question was also based on the U.S. Navy Wear Test and User Evaluation of Enlisted Utility Uniforms: Durability q13, which asked the participant to select all areas that had durability problems on their shirt, (a) arms, (b) back, (c) chest, (d) collar, (e) front, (f) cuff, (g) pockets, (h) seams, and (I) buttons (see Figure 37) (U.S. Navy Clothing and Textile Research Facility, 1998). This durability question was modified to add snaps, zippers, and Velcro™ options as they are common on wildland firefighters' apparel (see Figure 37).

Select all areas that have durability problems on your pant.

Legs	Knee	Front	Seat	Waist	Ankle	Crotch	Pockets	Seams	Buttons or Snaps	Zippers	Velcro	Elastic	Buckle
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Select all areas that have durability problems on your shirt.

Arms	Back	Chest	Collar	Front	Cuff	Pockets	Seams	Buttons or Snaps	Zippers	Velcro
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Figure 37. Durability problem areas in wildland firefighters apparel

Design: Comfort, performance, don and doff. Comfort, performance, and donning and doffing were based on Huck et al. (1997) Wearer Acceptability Scale (see Figure 38) originally

Place a check between each pair of adjectives at the location that best describes how you feel:

1.	Comfortable	9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1*	Uncomfortable
2.	Acceptable	9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1	Unacceptable
3.	Tired	1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9	Rested

Place a check between each pair of adjectives at the location that best describes the clothing you are wearing:

4.	Flexible	9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1	Stiff
5.	Easy to put on	9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1	Hard to put on
6.	Freedom of movement of arms	9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1	Restricted movement of arms
7.	Easy to move in	9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1	Hard to move in
8.	Satisfactory fit	9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1	Unsatisfactory fit
9.	Freedom of movement of legs	9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1	Restricted movement of legs
10.	Freedom of movement of torso	9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1	Restricted movement of torso
11.	Dislike	1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9	Like
12.	Loose	9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1	Tight
13.	Crotch of overall right distance from body	9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1	Crotch of overall too close or too far from body

* Number added for reader reference only

Figure 38. Wearer acceptability scale (Huck et al., 1997)

rated on a 9-point semantic differential scale and Rutherford-Black and Khan (1995) Uniform Performance Scale (see Figure 39) originally rated on a 7-point semantic differential scale.

CHARACTERISTICS

Comfortable/Uncomfortable
Not Sturdy/Sturdy
Cold/Hot
Not Casual/Too Casual
Wrinkled/Crisp Appearance
Harsh/Soft To The Skin
Machine/Not Machine Washable
Not Easy Care/Easy Care
Durable/Not Durable
Absorbent/Nonabsorbent
Low Quality/High Quality
Breathable/Does Not Breathe
Feels Soft/Stiff
Impractical/Practical
Nonfunctional/Functional
Lightweight/Heavyweight
Irritating/Non-Irritating
High Static/Low Static

Figure 39. Uniform performance scale (Rutherford-Black & Khan, 1995)

Neither of these researchers reported scale reliability but other researchers have used these scales and reported a Cronbach *alpha* of .89 (Fowler, 1999) and .90 (Barker & Black, 2009). These scales were modified to rate performance, comfort, and donning and doffing of wildland firefighters' apparel on a 7-point semantic differential scale. Performance was rated with: (a) flexible/stiff, (b) freedom of/restrict movement in legs, (c) freedom of/restrict movement of arms, (d) functional/not functional, (e) loose/tight, and (e) like/dislike, and (f) acceptable/unacceptable (see Figure 40). Comfort was rated with: (a) comfortable/uncomfortable, (b) cold/hot, (c) soft/harsh to the skin, (d) breathable/does not breath, (e) lightweight/ heavyweight, (f) non-irritating/irritating, and (g) low static/high static. This was followed by an open-ended comfort question asking if they would change or improve the comfort of the pant or shirt, and what would it be? Donning was rated with easy/hard to put on while doffing was rated with easy/hard to remove.

Select a location between the pair of adjectives at the location that best describes how you feel about your wildland firefighting pant.

Comfortable	○ ○ ○ ○ ○ ○ ○	Uncomfortable
Acceptable	○ ○ ○ ○ ○ ○ ○	Unacceptable
Flexible	○ ○ ○ ○ ○ ○ ○	Stiff
Easy to put on	○ ○ ○ ○ ○ ○ ○	Hard to put on
Freedom of movement in legs	○ ○ ○ ○ ○ ○ ○	Restrict movement in legs
Like	○ ○ ○ ○ ○ ○ ○	Dislike
Loose	○ ○ ○ ○ ○ ○ ○	Tight
Sturdy	○ ○ ○ ○ ○ ○ ○	Not sturdy
Cold	○ ○ ○ ○ ○ ○ ○	Hot
Soft to the skin	○ ○ ○ ○ ○ ○ ○	Harsh to the skin
Breathable	○ ○ ○ ○ ○ ○ ○	Does not breath
Easy to remove	○ ○ ○ ○ ○ ○ ○	Hard to remove
Functional	○ ○ ○ ○ ○ ○ ○	Not functional
Lightweight	○ ○ ○ ○ ○ ○ ○	Heavyweight
Non-irritating	○ ○ ○ ○ ○ ○ ○	Irritating
Low Static	○ ○ ○ ○ ○ ○ ○	High Static

Figure 40. Comfort, performance, don and doff questions in wildlife firefighter's apparel

Design: Components. The components question used a 7-point satisfaction scale (1 = Extremely satisfied; 7 = Extremely dissatisfied) along with a not applicable field and listed the components currently found in wildland firefighters' apparel. Participants were instructed to indicate their level of satisfaction with the components on their firefighting apparel in the following areas: (a) D rings, (b) buckle, (c) gear loops, (d) vents, (e) chest pocket size, (f) chest pocket location, (g) arm pocket size, (h) arm pocket location, (i) belt loops, (j) back pocket size, (k) back pocket location, (l) pant slash pocket size, (m) pant slash pocket location, (n) thigh pocket size, (o) thigh pocket location, (p) crotch reinforcement panel, (q) reflective materials/strips, (r) back pleat, (s) contoured knees, (t) radio pocket size, and (u) radio pocket location (see Figure 41).

Indicate your level of satisfaction with the design details on your firefighting apparel.

	Extremely satisfied	Moderately satisfied	Slightly satisfied	Neutral	Slightly dissatisfied	Moderately dissatisfied	Extremely dissatisfied	× Not applicable
D rings								
Buckle								
Gear loops								
Vents								
Chest pocket size								
Chest pocket location								
Arm pocket size								
Arm pocket location								
Belt loops								
Back pocket size								
Back pocket location								
Pant slash pocket size								
Pant slash pocket location								
Thigh pocket size								
Thigh pocket location								
Crotch reinforcement panel								
Reflective materials/strips								
Back pleat								
Contoured knees								
Radio pocket size								
Radio pocket location								

Figure 41. Satisfaction of components in wildland firefighters apparel.

Design: Closures. The closures question used a 7-point satisfaction scale (1 = Extremely satisfied; 7 = Extremely dissatisfied) along with a not applicable field and list closures currently found in wildland firefighters' apparel. Participants were instructed to indicate their level of satisfaction with the closures on their firefighting apparel in the following areas: (a) buttons, (b) snaps, (c) zippers, (d) Velcro™, (e) zipper pulls, (f) pocket flap closures, and (g) gusset ankle (zipper closure) (see Figure 42).

Indicate your level of satisfaction with the closures on your firefighting apparel.

	Extremely satisfied	Moderately satisfied	Slightly satisfied	Neutral	Slightly dissatisfied	Moderately dissatisfied	Extremely dissatisfied	Not applicable
Buttons								
Snaps								
Zippers								
Velcro								
Zipper pulls								
Pocket flap closures								
Gusset ankle (zipper closure)								

Figure 42. Satisfaction of closures in wildland firefighters apparel.

Production: Sizing system. The next section investigated sizing and fit for the wildland firefighers' (a) pant and (b) shirt. Instructions tell participants to think about the wildland firefighting (a) pants and (b) shirt they typically wear while working and answer the questions. The sizing system question was open-ended and asked what size they preferred to wear for their firefighting (a) pant and (b) shirt with a box to type their response for the (a) pant and (b) shirt (see Figure 43).

For the following questions, think about your wildland firefighting pants you typically wear while working.

What size do you prefer to wear for your firefighting pants?

Figure 43. Sizing system question for wildland firefighting apparel

Production: Quality and ease of care. Quality and ease of care questions were based on Rutherford-Black and Khan (1995) Uniform Performance Scale and used a 7-point semantic differential scale (see Figure 44) that was modified to be a 9-point semantic differential scale

CHARACTERISTICS

Comfortable/Uncomfortable
Not Sturdy/Sturdy
Cold/Hot
Not Casual/Too Casual
Wrinkled/Crisp Appearance
Harsh/Soft To The Skin
Machine/Not Machine Washable
Not Easy Care/Easy Care
Durable/Not Durable
Absorbent/Nonabsorbent
Low Quality/High Quality
Breathable/Does Not Breathe
Feels Soft/Stiff
Impractical/Practical
Nonfunctional/Functional
Lightweight/Heavyweight
Irritating/Non-Irritating
High Static/Low Static

Figure 44. Uniform performance scale (Rutherford-Black & Khan, 1995)

(see Figure 45). Quality was rated with (a) high quality/low quality and (b) sturdy/not sturdy. Ease of care was rated with (a) ease care/not easy to care and (b) machine washable/not machine washable.

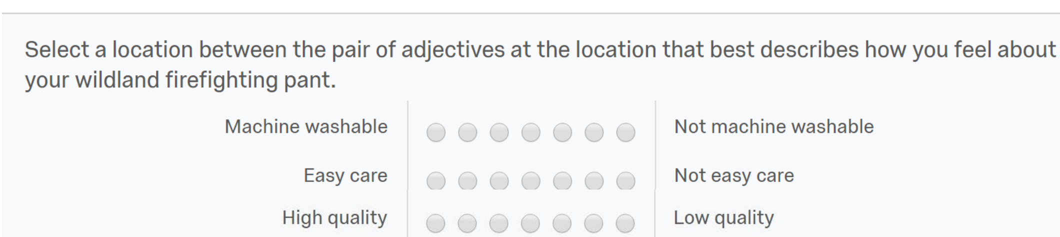


Figure 45. Quality and ease of care questions in wildlife firefighter's apparel

Production: Availability. The availability question used a 7-point semantial differential scale (1 = Rarely available; 7 = Always available) and asked participants to rate the availability of their firefighting apparel when you went to purchase it (see Figure 46). This was followed by a question that asked where the participants normally purchased their firefighting apparel with response options of (a) online / website, (b) retail store, (c) mail order, and (d) employer provided.

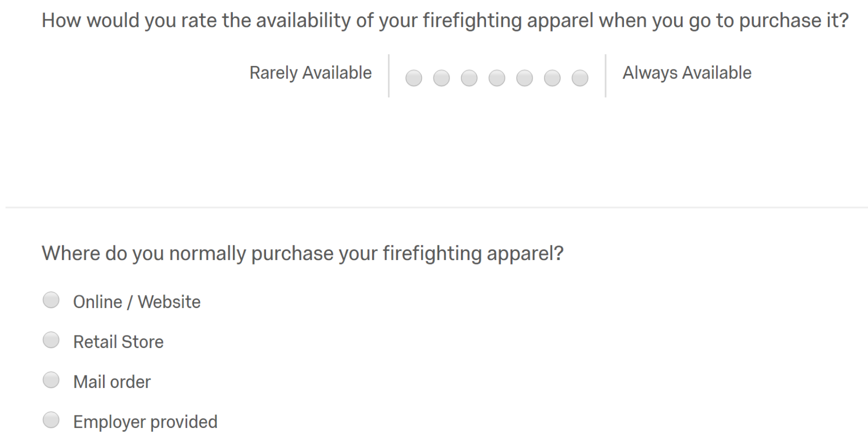


Figure 46. Wildland firefighters' apparel availablity questions.

Other reasons. To investigate if there was additional information the researchers should know, an open-ended question was posed. This open-ended question asked if there was any additional information about how firefighting apparel could be improved; a multiline text box was provided below the question for the participant to use.

Demographics. The demographic section of the questionnaire asked the participant's age, occupation or title, years of experience as a wildland firefighter, marital status, state of residence, and ethnicity.

Face validity. Pilot testing was conducted with a wildland firefighter, along with a researcher to improve the clarity of questions and the formatting of the questionnaire prior to the main study. Feedback from the pilot testing was reviewed by the researcher and committee members to evaluate what revisions if any were needed based on the feedback. Researchers established no changes were necessary for the questionnaire. This pilot test established face validity of the questionnaire.

Data collection procedures. Wildland firefighter companies distributed the online questionnaire through the unique hyperlink addresses along with a project summary for their employees. Wildland firefighters interested in participating were instructed to click on the hyperlink to begin the questionnaire. The questionnaire contained an IRB approved Information Letter that discussed the purpose of the study, potential risks and discomforts, benefits, compensation, confidentiality, voluntary participation and withdrawal, consent, incentives, and contact information for the study. The participant clicked the forward button to begin the questionnaire. Once the questionnaire was completed, the participant was thanked for his/her time and directed to a separate website for a chance to win a $50 Amazon.com e-gift card.

Data analysis. Questionnaire data were exported from Qualtrics.com in SPSS format and imported into SPSS version 24.0 statistical software. Prior to analysis, the data were cleaned, and all errors or anomalies were identified and corrected. Descriptive statistics were used to analyze the sample characteristics and scale responses. A table showing each item, along with the mean, frequency, and percentages, was developed. Scale reliability was analyzed using Cronbach's *alpha* coefficient for each of the measures with more than one item.

Open-ended questions were analyzed using a content analysis approach. The questionnaire responses were exported from SPSS and placed into an Excel spreadsheet for analysis. A coding scheme for each research question was generated based on the meaningful segments of the responses. These segments were organized into themes. The researcher condensed the themes for each open-ended question. A coding guide for each question was then developed that included codes, names, definitions, and example comments for each theme. Two coders, along with a third for mediation, coded all the open-ended questions. Once all data had been coded, they were imported into SPSS for analysis. Each of the coders were assigned to a categorical variable and then a corresponding numerical value for each theme name based on the coding guides. Inter-coder reliability analysis was done with a Kappa statistic in SPSS to determine the consistency between coders for each open-ended question and reported in a table. The coded results were cross tabulated in SPSS to compare the two coders' results, which revealed the most frequently repeated themes. Results were reported by theme, frequency, and typical comments for each open-ended research question.

The following research questions were investigated in study 2:

Research Question 1. What are wildland firefighters' perceptions of their NFPA 1977 Protective Clothing based on the *end-user dimension* of the Multidimensional Functional Apparel Framework (MFAF): (a) affordability.

(a) Affordability. Descriptive statistics were used to report the frequency and percentages of affordability in wildland firefighters pants and shirts in NFPA 1977 apparel.

Research Question 2. What are wildland firefighters' perceptions of their NFPA 1977 Protective Clothing based on the *task dimension* of the Multidimensional Functional Apparel Framework (MFAF): (a) protection, (b) NFPA 1977 regulations, and (c) equipment interactions.

(a) Protection. This was an open-ended question, so it was analyzed using a content analysis approach that grouped participant responses based on theme. Descriptive statistics were then used to report the protection problems based frequency and percentage of themes mentioned.

(b) NFPA 1977 Regulations. This was categorical, so descriptive statistics were used to report the frequency and percentages of firefighters' understanding if their apparel met regulations and the perceived differences between NFPA 1977 editions from 2005 to 2016.

(c) Equipment Interactions. This was an open-ended question, so it was analyzed with a content analysis approach by grouping the participant responses based on theme. Descriptive statistics were then used to report the equipment interactions based on frequency and percentage of mentioned themes.

Research Question 3. What are wildland firefighters' perceptions of their NFPA 1977 Protective Clothing based on the *design dimension* of the Multidimensional Functional Apparel Framework (MFAF): (a) fit, (b) body shape, (c) mobility, (d) comfort, (e) durability, (f) performance, (g) donning and doffing ease, (h) components, and (i) closures.

(a) Fit (pant and shirt). ANOVAs were run separately for the pants and shirt. Repeated-measures ANOVA was done for the pants with 8 levels (pant areas) and was used to assess firefighters' fit satisfaction for NFPA 1977 pants by comparing the means of the 8 fit pant areas. If the ANOVA revealed a significant difference, a Tukey's HSD post hoc analysis was performed to determine which pairwise comparison was significantly different. Repeated-measures ANOVA was done for the shirts with 9 levels (shirt areas) was used to assess fit satisfaction of firefighters NFPA 1977 shirts by comparing the means of the 9 fit shirt areas. If the ANOVA revealed a significant difference, a Tukey's HSD post hoc analysis was performed to determine which pairwise comparison was significantly different. Additionally, two open-ended questions, "If you could change the fit of the pant, what would you change?" and "If you could change the fit of the shirt, what would you change?" were asked of the participants. Content analysis was used to analyze the results and a table was created to feature the themes and a sample of the participants' responses.

(b) Body shape. This was categorical, so descriptive statistics were used to report the frequency and percentages of the number of participants in each body shape per gender. Descriptive statistics reported frequency and percentages of firefighters' body shapes by gender.

(c) Mobility. This was categorical, so descriptive statistics were used to report the frequency and percentages of the number of participants experiencing mobility issues in each area for the pant and shirt.

(d) Comfort (pant and shirt). Descriptive statistics were used to assess the comfort of NFPA 1977 apparel. A mean composite measure was then created for each of the 7 bipolar adjective pairs, and the mean for each pair was reported. Additionally, a one-sample *t*-test was performed to investigate if participants' comfort perceptions of pant and shirt were different. This was followed by a comfort open-ended question, which it was analyzed with content analysis by breaking down the participants' responses based on themes. Description statistics was used to report the comfort problems by frequency and percentage of theme.

(e) Durability. This was categorical, so descriptive statistics were used to report the frequency and percentages of firefighters' durability problems for NFPA 1977 pants and shirts.

(f) Performance (pant and shirt). Descriptive statistics were used to assess the overall performance of NFPA 1977 apparel. A mean composite measure was created for each of the 7 bipolar adjective pairs, and the mean for each pair was reported. Additionally, a one-sample *t*-test was performed to investigate if participants' perceptions of pant and shirt performance were different.

(g) Donning and doffing ease. Descriptive statistics were used to report the frequency and percentages of the ease of donning then the ease of doffing of NFPA 1977 apparel.

Additionally, one-sample *t*-test was performed to investigate if participants' perceptions of pant and shirt donning and doffing ease is different.

(h) Components. Descriptive statistics was used to report the mean and standard deviation of satisfaction levels on 21 different components in the firefighters NFPA 1977 apparel in a table.

(i) Closures. Descriptive statistics was used to report the mean and standard deviation of satisfaction levels on seven different closures found in the firefighters NFPA 1977 apparel in a table.

Research Question 4. What are wildland firefighters' perceptions of their NFPA 1977 Protective Clothing based on the production dimension of the Multidimensional Functional Apparel Framework (MFAF): (a) sizing system, (b) quality, (c) ease of care, and (d) availability.

(a) Sizing system. This was categorical, so descriptive statistics were used to report the frequency and percentages of firefighters sizing for NFPA 1977 pants and shirts.

(b) Quality (pant and shirt). A mean composite measure was be created for quality of wildland firefighters pants and another for wildland firefighters shirts based on a 7-point semantic scale; descriptive statistics were used to report the frequency and percentages of the quality of NFPA 1977 apparel. Additionally, a one-sample *t*-test was performed to investigate if participants' quality perceptions of pant and shirt were different. A figure showing the mean for each pair based on the quality for pants and shirts is created.

(c) Ease of care (pant and shirt). A mean composite measure was be created for ease of care of wildland firefighters' pants and another for wildland firefighters' shirts based on a 7-point semantic scale; descriptive statistics were used to report the frequency and percentages of the ease of care of NFPA 1977 apparel. Additionally, a one-sample *t*-test was performed to investigate if participants perceptions of pant and shirt ease of care is different.

(d) Availability. Descriptive statistics were used to report the mean and standard deviation on the availability of firefighting NFPA 1977 apparel on a 7-point availability scale (1=Rarely available; 7=Always available), followed by purchase locations, which was categorical. Descriptive statistics were used to report the frequency and percentages of locations where NFPA 1977 apparel was typically purchased.

Research Question 5. Are there any preferences for a specific NFPA 1977 edition apparel?

This was categorical, so descriptive statistics were used to report the frequency and percentages of any differences in editions.

CHAPTER 4. RESULTS

This study proposed to develop and apply the Multidimensional Functional Apparel Framework (MFAF) using two separate case studies that examined different ages, genders, and types of functional apparel categories, through use of mixed methods. The main purpose was to investigate to what extent the quantitative results agreed with the qualitative findings for each of the MFAF variables tested in the separate studies and what additional variables, if any, emerged from the gathering of quantitative data and qualitative open-ended question data in each of the studies. Each case study results are presented separately in this chapter.

Case Study 1 – Investigating Usage and Expectations for Children Sun Protective Apparel

Research Design

Case study 1 applied the proposed MFAF by investigating usage and expectations for sun protective apparel in children. Data was collected with a Qualtrics online survey through Centiment, a marketing agency, that specializes in consumer research by partnering with elementary schools and using online survey responses. All questions had forced answers, and only parents, family members or caregivers of a child (under 18 years of age) could participate. A total of 174 individuals were qualified to participate and completed the online survey. The data were exported from Qualtrics into SPSS software where it was verified that all data were usable. Scale reliabilities for all measures were established. Research questions were analyzed using content analysis, descriptive statistics, and repeated measures ANOVAs. Open-ended responses were coded by two coders using Excel. The coded data were then exported from Excel into SPSS software where inter-coder reliability was established. Each open-ended question was analyzed for frequency distributions. The results section for case study 1 consists of (1) scale reliability, (2) sample demographics, (3) research question analyses, and (4) open-ended question analyses.

Reliability Analysis

Scale reliabilities for measures were analyzed using Cronbach's *alpha* coefficient for each of measure with more than one item. The compliance measure had 3 items and revealed good reliability with a Cronbach's *alpha* coefficient of 0.94. The fit satisfaction measure had 16 items and revealed good reliability with a Cronbach's *alpha* coefficient of 0.97. Table 2 shows the reliability

Table 2

Reliability Analysis of Case Study 1 Measures

Items	*M*	*SD*	Cronbach's *alpha*	*n*
Compliance			**.94**	174
I intend to ensure this child wears sun protective apparel.	5.91	1.29		
I plan to ensure this child wears sun protective apparel.	5.83	1.33		
I want to ensure this child wears sun protective apparel.	5.86	1.32		
Fit Satisfaction			**.97**	110
Neckline	5.35	1.51		
Sleeve length	5.62	1.45		
Waist length	5.57	1.43		
Waist	5.53	1.49		
Abdomen	5.54	1.41		
Shoulder	5.76	1.30		
Armhole	5.62	1.33		
Upper arm	5.66	1.38		
Lower arm	5.61	1.36		
Elbow	5.63	1.40		
Pant length	5.60	1.46		
Short length	5.75	1.40		
Skirt length	5.72	1.38		
Crotch	5.68	1.41		
Thigh	5.65	1.37		
Buttocks	5.54	1.51		

Based on 7-point scale.

analyze of the measures. Differences in sample size were the result of not all participants having had experience with their child wearing sun protective clothing and therefore choosing “not applicable”.

Open-ended questions were analyzed using content analysis. Coding sheets with a code, category, and description were developed by the researcher from reviewing qualitative text received from the participants. A separate coding sheet was made for each of the three open-ended questions. The first open-ended question, “What are the reasons for not using or purchasing children’s sun protective apparel?” had 7 themes; (a) sunscreen preference, (b) affordability, (c) lack of product knowledge, (d) product availability, (e) child’s age, (f) aesthetic preferences, (g) sun protection, and (h) lack of perceived need (see Table 3).

Table 3

Coding Sheet for Perceived Deterrents

Theme #	Theme Label	Definition of Theme	Example Comments for Theme
1	Sunscreen preference	Comments about the type of sunscreen, brand name of a sunscreen, or the SPF rating of the sunscreen	“Coppertone Kids SPF 50” or “we use sunscreen”
2	Affordability	Comments about the cost of the apparel	“It is too expensive” or “I can’t afford it”
3	Lack of product knowledge	Comments that showed the participant was not aware that this specific type of product existed	“I didn’t know they existed” or “I wasn’t aware there was sun protective clothing”
4	Product availability	Comments that stated the product was not available to the participant	“They do not sell sun protective apparel where I shop” or “Sun protective apparel is difficult to find”
5	Child’s age	Specific age of the participants child	“He is a teenager” or “She is only a few months old”

Table 3 Continued

Theme #	Theme Label	Definition of Theme	Example Comments for Theme
6	Aesthetic preferences	Comments associated with specific aesthetically pleasing or non-pleasing preferences for sun protective apparel	“aqua”, “prints”, or “I don’t look good in sun protective apparel”
7	Sun protection	Comments associated with sunburns or damaging effects of the sun	“skin cancer” or “to avoid another sunburn”
8	Lack of perceived need	Comments that give the impression that their child did not need sun protective clothing	“He doesn’t burn” or “She doesn’t stay in the sun long enough to need it”

The second open-ended question, “What styles of sun protective apparel does your child prefer to wear outside in the water?” had 14 themes: (a) shirt preference, (b) shorts preference, (c) hat preference, (d) glasses preference, (e) swimwear preference, (f) pant preference, (g) skirt preference, (h) shoe preference, (i) sunscreen preference, (j) brand preference, (k) aesthetic preferences, (l) floatation device preference, (m) fit preference, and (n) no preference (see Table 4).

Table 4

Coding Sheet for Style Preferences of Sun Protective Apparel

Theme #	Theme Label	Definition of Theme	Example Comments for Theme
1	Shirt preference	Comments associated with the type of shirt	“long sleeve”, “t-shirt”, or “rash guard”

Table 4 Continued

Theme #	Theme Label	Definition of Theme	Example Comments for Theme
2	Shorts preference	Comments about the type of shorts worn	"swim trunks" or "water shorts"
3	Hat preference	Comments about the type of hat worn	"safari hat", "baseball cap", or "swim hat"
4	Glasses preference	Comments about the type of glasses worn to protect the eyes	"sunglasses" or "goggles"
5	Swimwear preference	Comments about the type of swimwear worn	"one-piece" or "normal swimsuit"
6	Pant preference	Comments about the type of pants worn	"long pants" or "swim pants"
7	Skirt preference	Comments about the type of skirt worn	"swim skirt" or "skort"
8	Shoe preference	Comments associated with the type of protective footwear worn	"water shoes" or "swim shoes"
9	Sunscreen preference	Comments were associated with the type of sunscreen worn	"waterproof sunscreen" or "SPF 25 or above"
10	Brand preference	Comments with the specific brand names associated with the sun protective apparel	"Columbia", "Hurley", or "Under Armour"
11	Aesthetic preferences	Comments associated with the aesthetic nature of the apparel	"bright colors" or "boys style"
12	Floatation device preference	References to a type of floatation device	"life vest" or "swim floaties"
13	Fit preference	Comments about the way the apparel fit on the child or the type fit of preference the child expressed	"tight fitting" or "loose fitting"
14	No preference	Comments that indicated the respondent did not have a preference	"it doesn't matter" and "whatever is available"

The third open-ended question, "Are there any other reasons why sun protective apparel does not fully satisfy your or your child's needs?", had 15 themes: (a) satisfaction with current options,

(b) swimwear preference, (c) sensory problems, (d) comfort problems, (e) fit problems, (f) donning and doffing problems, (g) product affordability, (h) lack of product knowledge, (i) fabric quality, (j) product availability, (k) wearing product compliance, (l) body shape, (m) protection problems, (n) mobility problems, and (o) construction quality (see Table 5).

Table 5

Coding Sheet for Other Reasons Sun Protective Apparel Does Not Satisfy Needs

Theme #	Theme Label	Definition of Theme	Example Comments for Theme
1	Satisfaction with current options	Comments that indicated the child's sun protective apparel was satisfactory	"very satisfied with sun protective apparel or "they satisfy my needs properly"
2	Swimwear preference	Comments referred to the type of swimwear worn by the child	"regular swimwear", "bikini", or "one-piece"
3	Sensory problems	Comments dealt with the child's sensory reaction to wearing sun protective apparel	"doesn't like the feeling of the fabrics", "sticks to body" or "sensitive skin"
4	Comfort problems	Comments associated with the comfort of the sun protective apparel	"uncomfortable" or "tight"
5	Fit problems	Comments referring to the way the apparel fit on the child	"it rides up", "fits weird", or "waist not adjustable"
6	Donning and doffing problems	Comments about the ease of getting in and out of the sun protective apparel	"hard to put on by themselves" and "too much trouble for him/her"
7	Product availability	Comments about the ability to find and purchase the apparel	"not available where I shop" or "I can't find one to buy locally"
8	Lack of product knowledge	Comments expressing the respondent did not know the product existed or that sun protective apparel was available to them	"did not know I could buy sun protective apparel" or "never heard of it before"
9	Fabric quality	Comments associated with respondents opinions of the fabric quality	"low quality fabric" or "better quality fabric needed"

Table 5 Continued

Theme #	Theme Label	Definition of Theme	Example Comments for Theme
10	Wearing product compliance	Comments on how they made sure the child kept the sun protective apparel on or placed it on	"he/she does not like it" or "my child will not wear it", or "my child knows he/she has to wear it"
11	Body shape	Comments were associated with the child's body shape	were "not ideal for child in diapers" or "it doesn't work well with husky body type"
12	Protection problems	Comments about protecting the child from the sun	"my child needs sun protection" or "must protect from UV rays"
13	Product affordability	Comments associated with the cost or price of the sun protective apparel	"it is expensive" and "high prices"
14	Mobility problems	Comments referred to the child's ability to move in the apparel	"not completely free to move around in them" or "restrictive"
15	Construction quality	Comments about how well made the apparel was	"better made" or "seams torn"

Texts from participant responses were imported into an Excel spreadsheet so that it could be given to trained qualitative coders. Each question was a separate tab in one Excel file. To establish intercoder-reliability, two graduate students from the Department of Consumer and Design Sciences at Auburn University were recruited to code the open-ended responses. All graduate coders had two or more years of content analysis coding experience. The Excel spreadsheet and coding sheets were emailed to each coder for each open-ended question. Once the coder was done with coding, the code numbers for each response was input into SPSS software for intercoder reliability. Intercoder reliability was established for the open-ended questions by cross tabulating each of the coders' results and are reported in Table 6 with the Kappa statistic, number of themes, and number of valid cases.

Table 6

Intercoder Reliability of Open-ended Questions

Question	Kappa	N of Themes	N of Valid Cases
What are the reasons for not using or purchasing children's sun protective apparel?	.897	8	36
What styles of sun protecive apparel does you child prefer to wear outside in the water?	.966	14	175
Are there any other reasons why sun protective apparel does not fully satisfy you or your child's needs?	1.000	16	54

Sample Demographics

The sample consisted of 174 participants, 94 males (54.0%) and 80 females (46.0%), with an age range from 19 to 59 years and mean age of 38 years. Participants were mostly parents (94.2%) with 97 (55.7%) male children, 69 female (39.7%) children, and 8 unidentified (4.6%) (preferred to not state gender). The children ranged from under one year of age to 19 years of age with a mean age of 8.5 years. Participants were mostly married (66.1%), Caucasian (72.4%) and had a high school education (43.7%). Participants represented 43 different states (see Figure 53) with the majority from the Northeast (40%); no state had representation of over 10%. Table 7 reports the frequencies and percentages associated with participants' gender,

Table 7

Case Study 1 - Characteristics of Sample

Demographic Characteristic	Frequency *(n=174)*	Percentage
Participant Gender		
Male	**94**	**54.0%**
Female	80	46.0%

Table 7 Continued

Demographic Characteristic	Frequency *(n=174)*	Percentage
Participant Age		
19-24	5	2.8%
25-34	58	33.3%
35-44	**73**	**42.0%**
45-54	29	16.7%
55 and up	9	5.1%
Relationship to Child		
Parent	**164**	**94.2%**
Family Member	10	5.8%
Child Gender		
Male	**97**	**55.7%**
Female	69	39.7%
Prefer to not state	8	4.6%
Child Age		
0-3	36	20.7%
4-7	37	21.3%
8-11	**51**	**29.3%**
12-15	33	19.0%
16 +	17	9.7%
Residence		
Northeast	**66**	**40.0%**
South	50	28.7%
West	31	17.8%
Midwest	27	15.5%
Marital Status		
Never married	31	17.8%
Married	**115**	**66.1%**
Divorced	18	10.3%
Separated	6	3.4%
Widowed	4	2.3%
Ethnicity		
Caucasian	**126**	**72.4%**
African American	20	11.5%
Hispanic	14	8.0%
Asian	8	4.5%
American Indian/Alaska Native	3	1.8%
Other	3	1.8%
Education		
High School Degree	**76**	**43.7%**
Some College/Technical School	20	11.5%
Bachelor’s	56	32.3%
Graduate Degree	20	11.5%

participants' age, child's gender, child's age, residence, marital status, ethnicity, and education. Figure 47 is a participant residency map of the U.S. showing participant numbers for each state and colored by West, Midwest, Northeast, and South.

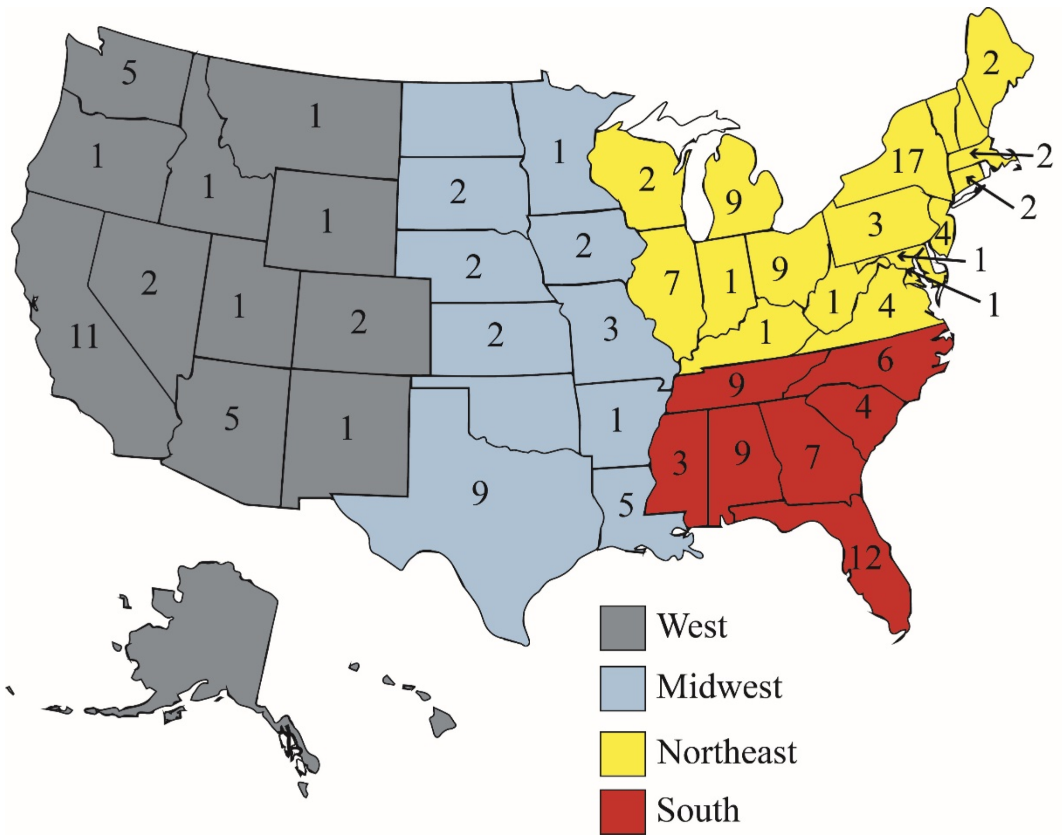


Figure 47. Case study 1 – U.S. residency map of participants (n=174)

Sun protective characteristics of the sample revealed children were outside swimming or playing in the water on an average of 3 hours 36 minutes per day on weekdays and 3 hours and 44 minutes on weekends. The skin sensitivity of the child to the sun was diverse because each skin type was represented (see Table 8) but most of the children were reported as having skin types that "sunburn sometimes and tan slowly" (20.1%) or "sunburn a little and usually tan" (18.4%). Less than half (47.4%) of the children did not receive a sunburn in the last 12 months,

Table 8

Case Study 1 – Sun Protective Characteristics of Sample

Sun Protective Characteristic	Frequency (*n=174)*	Percentage
Did you know the Centers for Disease Control and Prevention (CDC) and The Skin Cancer Foundation states the best sun protection is ultraviolet (UV) clothing?		
Yes	78	44.8%
No	**96**	**55.2%**
Does this knowledge change your feelings about sun protective apparel?		
Yes	**93**	**53.4%**
No	81	46.6%
Sun Protective Apparel Ownership		
Yes	**142**	**81.6%**
No	32	18.4%
History of sunburn in past 12 months		
Yes	**91**	**52.3%**
No	83	47.7%
Child's Sun Sensitivity		
Sunburn easily and are not likely to tan.	23	13.2%
Usually sunburn easily and tan a little.	33	19.0%
Sunburn sometimes and tan slowly.	**35**	**20.1%**
Sunburn a little and usually tan well.	32	18.4%
Rarely sunburn, and tan deeply.	27	15.5%
Almost never sunburn.	24	13.8%

while the remaining participants on average reported one or two sunburns in the last 12 months (M = 1.68). Over half the participants did report their child had experienced a sunburn in the last 12 months (53.3%), and they were not aware that sun protection apparel was the best sun protection (55.2%). However, knowing this did change their feelings about sun protective apparel (53.3%). Additionally, many of the children currently owned or had previously owned sun protective apparel (81.6%). The participants responded that the children wore mostly sunscreen (32.3%) for protection, followed by shorts (18.5%), sun glasses (15.2%), short sleeve shirts (15.0%), long sleeve shirts (6.1%), wide brimmed hat (5.7%), pants (5.1%), and skirts (2.0%) (see Figure 48). Table 8 reports the frequencies and percentages associated with the participants' knowledge of sun protective guidelines, sun protective apparel ownership, and the child's sun sensitivity.

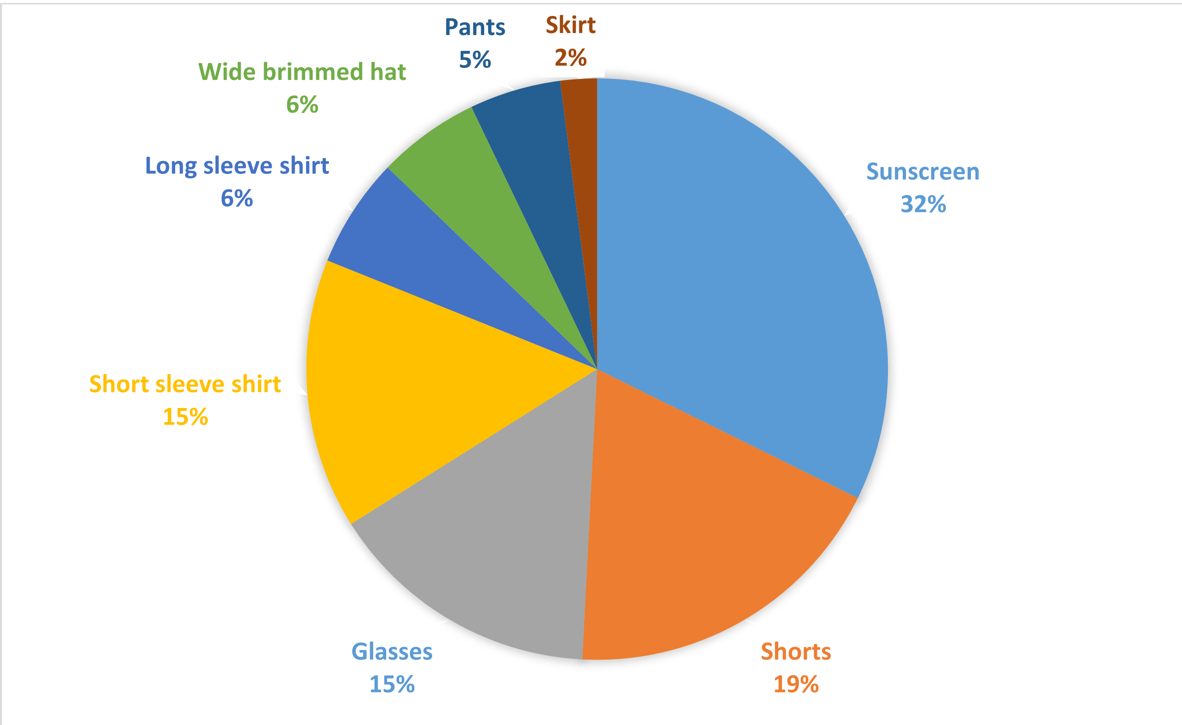


Figure 48. Types of sun protection worn by child outside while swimming or playing in the water.

Research Questions Analysis

Research question 1: What perceived deterrents, if any, do parents have for using sun protective clothing on their child(ren)? This open-ended question, "What are the reasons for not using or purchasing children's sun protective apparel? List all the reasons below." revealed 8 themes from 36 responses that were relevant to the study – child's age, aesthetic preferences, affordability, sun protection, product availability, lack of product knowledge, sunscreen use, and lack of perceived need (see Figure 49). Descriptive statistics revealed

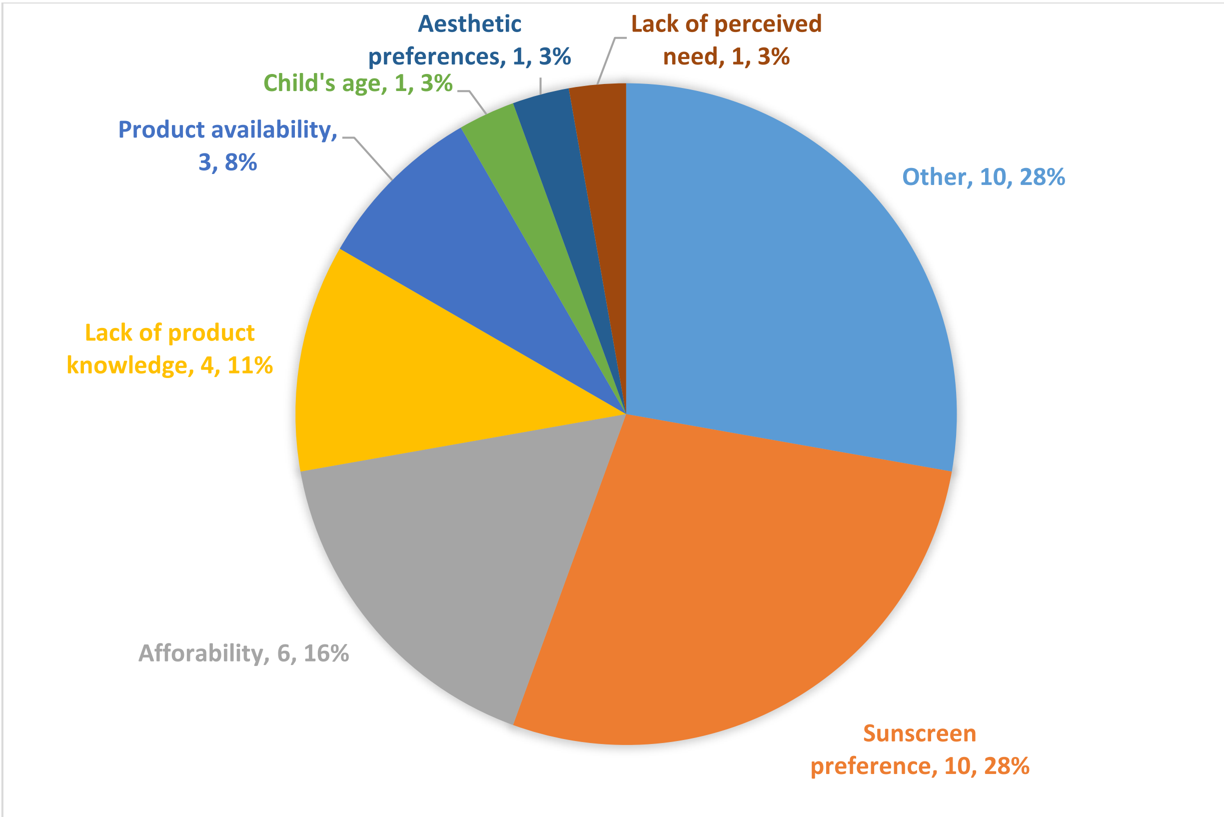


Figure 49. Pie chart of perceived deterrents and responses of wearing children sun protective apparel.

that sunscreen was preferred by the parent or caregiver for sun protection (27.8%) "other" reasons resulted in the same number of responses (27.8%) but were very broad. Affordability (16.7%), lack of product knowledge (11.1%), product availability (8.3%), child's age (2.8%), aesthetic preferences (2.8%), and sun protection (2.8%), were decreasing importance. Table 9

Table 9

Participant Sample Responses for Perceived Deterrents

Theme	Perceived Deterrent Responses
Sunscreen preference	"We use sunscreen", "I buy sunblock", "wears sunscreen", "Would rather wear sunscreen", and "sunscreen at least 50 SPF"
Affordability	"haven't been able to afford it", "didn't have the money", "Too expensive", and "cost too much"

Table 9 Continued

Theme	Perceived Deterrent Responses
Lack of product knowledge	"didn't think to check for sun protective apparel", "I feel it's unnecessary", "never seen sun protective specific apparel", and "don't know what is and is not sun protective"
Product availability	"I really do not see a lot of sun protective apparel", "not available in stores I shop", and "not readily available", "I never used it as a kid",
Child's age	"she is only 6 months"
Aesthetic preferences	"can't find a style she likes"
Sun protection	"to protect against the sun"
Lack of perceived need	"I don't know", "not usually in the sun", "my child does not sunburn", "didn't like it", and "limit the time outside"

features each theme and a sample of participant.

Research question 2: What are the parental preferences for sun protective apparel styles in children based on the *end-user dimension* of the Multidimensional Functional Apparel Framework (MFAF); aesthetic influences: styles? The open-ended question, "What styles of sun protecive apparel does you child prefer to wear outside in the water? List all the reasons below." revealed 14 themes generated from a total of 175 responses that were relevant to the study – shirt preference, shorts preference, hat preference, glasses preference, swimwear preference, pant preference, skirt preference, shoe preference, sunscreen preference, brand preference, aesthetic preference, floatation device preference, fit preference, and no preference (see Table 10).

Table 10

Participant Sample Responses for Style Preference

Themes	Style Preference Responses
Shirt preference	"shirt", "long sleeve", "t-shirt", "short sleeve tight tee", v-neck long sleeve", rash guard", "full sleeve", "protective shirt", "swim shirts" and "water shirts"
Shorts preference	"shorts", "swim trunks", and "swim shorts"
Hat preference	"hats", "brimmed hat", "sun hat", "safari style" and "baseball hat"
Glasses preference	"shades", "sunglasses", and "goggles"
Swimwear preference	"bathing suit", "one-piece suit", "body suit", and "swimsuit"
Pant preference	"pants"
Skirt preference	"skirts"
Shoe preference	"water shoes"
Sunscreen preference	"sunscreen", "SPF sunscreen lotion", "sun block", "lotion", "Coppertone kids sun protection", "waterproof sunscreen", and "non-scented"
Brand preference	"Columbia", "Hurley", "Patagonia", "Under Armour", and "Walmart"
Aesthetic preferences	"aqua", "bright colors", and "boys style"
Floatation device preference	"floats" and "life jacket"
Fit preference	"loose fitting"
No preference	"anything" and "whatever is available"

Descriptive statistics revealed shirts were the most preferred at 26% of the responses, followed by shorts (16%) sunscreen preference (15%), glasses (11%), swimwear preference (10%), hat preference (7%), brand preference (4%), no preference (3%), aesthetic preferences (2%), floatation device preference (2%), pant preference (2%), then skirt, shoes, and fit each were under 1%. Table 10 features each theme and a sample of the participant responses. Response totals for each theme are reported in Figure 50 as a colored pie chart.

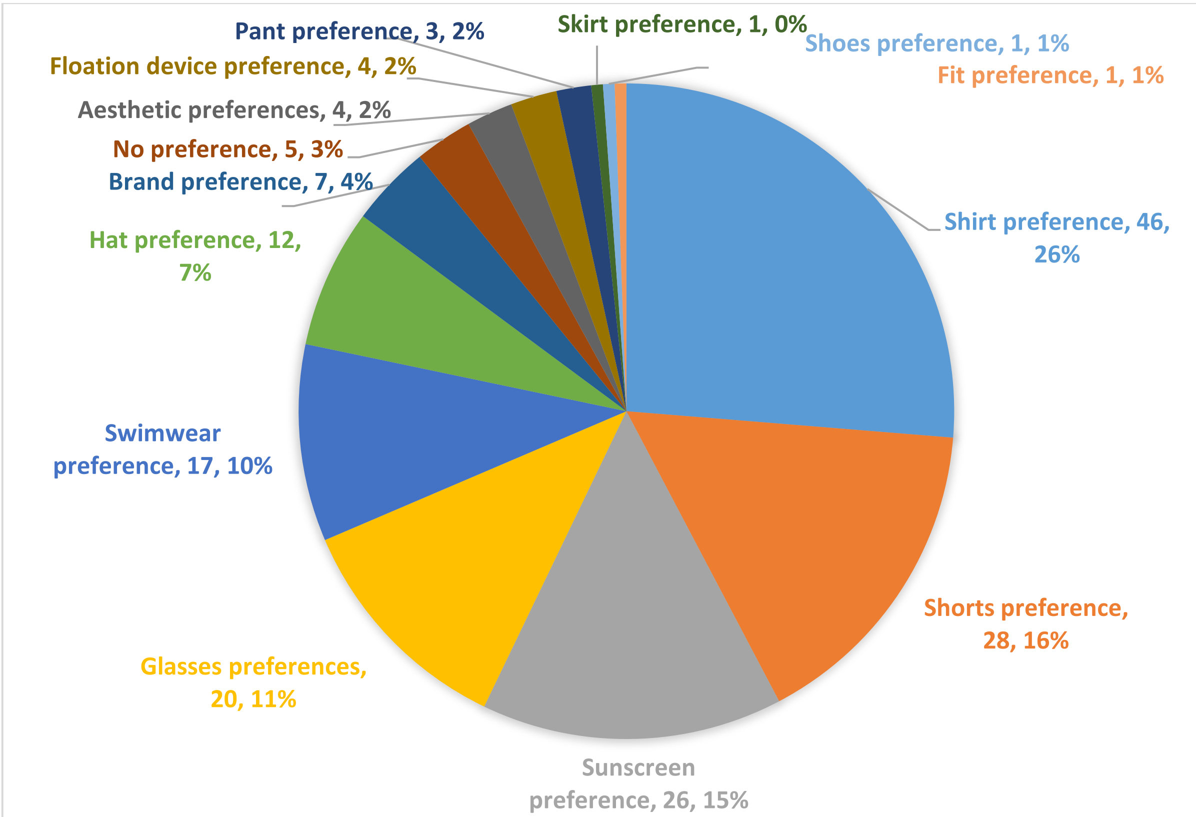


Figure 50. Pie chart of style preference in children sun protective apparel.

Research Question 3: At what level are children's sun protective apparel fulfilling the parent's expectations for the *end-user dimension* of the Multidimensional Functional Apparel Framework (MFAF); (a) affordability. The descriptive statistics show that most parents "somewhat" agree sun protective apparel is affordable with a mean of 5.18 (1=Strongly disagree, 2=Disagree, 3=Somewhat disagree, 4=Neither agree nor disagree, 5=Somewhat agree, 6=Agree, and 7=Strongly agree) and a standard deviation of 1.27.

Research Question 4: At what level are children's sun protective apparel fulfilling the parent's expectations for the *task dimension* of the Multidimensional Functional Apparel Framework (MFAF); (a) protection from the sun, (b) compliance, and (c) textiles.

The descriptive statistics for the task dimension variables are presented in Table 11 and reports an "agree" level for their expectations that sun protective apparel is protecting their child from the sun, and high levels of "somewhat" agreement for their child complying with using sun protective apparel and their expectations for the textiles used in the apparel.

Table 11

Case Study 1 – Task Dimension of MFAF (n=174)

Variables	*M*	SD
Protection from the sun	5.91	.97
Compliance	5.87	1.23
Textiles	5.83	.93

Note. 1=Strongly disagree, 2=Disagree, 3=Somewhat disagree, 4=Neither agree nor disagree, 5=Somewhat agree, 6=Agree, and 7=Strongly agree

Research Question 5: At what level are children's sun protective apparel fulfilling the parent's expectations for the *design dimension* of the Multidimensional Functional Apparel Framework (MFAF); (a) fit, (b) body shape, (c) mobility, (d) durability, (e) comfort, and (f) donning and doffing ease. Fit was analyzed with repeated-measures ANOVA with 16 levels (body areas) assessing fit satisfaction. The means and standard deviations for fit satisfaction in each of the 16 body areas are presented in Table 12. The results for the ANOVA indicated there was no statistically significant difference in the different areas of fit satisfaction, $F(15, 95) = 1.275$, $p = .233$. Participants agreed their fit satisfaction was fulfilled at all 16 levels. Descriptive statistics for remaining design dimension variables indicate body shape, mobility, durability, comfort, and donning ease had high "somewhat" agree levels. The fit satisfaction, body shape, mobility, durability, comfort, and ease of donning and doffing means and standard deviations of the MFAF design dimension are reported in Table 12.

Table 12

Case Study 1 – Design Dimension of MFAF (n=174)

Variables	*M*	SD
Fit satisfaction		
Neckline	5.35	1.51
Waist	5.53	1.49
Abdomen	5.54	1.41
Buttocks	5.54	1.51
Waist length	5.57	1.43
Pant length	5.60	1.46
Lower arm	5.61	1.36
Sleeve length	5.62	1.45
Armhole	5.62	1.33
Elbow	5.63	1.40
Thigh	5.65	1.37
Upper arm	5.66	1.38
Crotch	5.68	1.41
Shirt length	5.72	1.38
Short length	5.75	1.40
Shoulder	5.76	1.30
Body Shape	5.80	1.14
Mobility	5.95	1.19
Durability	5.86	.99
Comfort	5.68	1.19
Donning ease	5.76	1.12
Doffing ease	5.62	1.11

Note. 1=Strongly disagree, 2=Disagree, 3=Somewhat disagree, 4=Neither agree nor disagree, 5=Somewhat agree, 6=Agree, and 7=Strongly agree

Research Question 6: At what level are children's sun protective apparel fulfilling the parent's expectations for the *production dimension* of the Multidimensional Functional Apparel Framework (MFAF); (a) sizing system, (b) construction, (c) quality, (d) ease of care, and (e) availability. The descriptive statistics for the production dimension variables presented in Table 13 show a high level of "somewhat" agreement for quality, ease of case, and construction while sizing system and availability has lower "somewhat" agree levels.

Table 13

Case Study 1 – Production Dimension of MFAF (n=174)

Variables	*M*	SD
Sizing system	5.66	1.12
Construction	5.85	1.07
Quality	5.91	.96
Ease of care	5.87	.97
Availability	5.57	1.19

Note. 1=Strongly disagree, 2=Disagree, 3=Somewhat disagree, 4=Neither agree nor disagree, 5=Somewhat agree, 6=Agree, and 7=Strongly agree.

Open-ended comments. The open-ended question, "Are there any other reasons why sun protective apparel does not fully satisfy you or your child's needs?" revealed 16 themes from a total of 36 responses that were relevant to the study: (a) satisfaction with current options, (b) swimwear preference, (c) sensory problems, (d) comfort problems, (e) fit problems, (f) donning and doffing problems, (g) product affordability, (h) lack of product knowledge, (i) fabric quality, (j) product availability, (k) wearing product compliance, (l) body shape, (m) protection problems, (n) mobility problems, and (o) construction quality. Descriptive statistics revealed satisfaction with current options were the most common at 20.4% of the responses, followed by fit problems (14.8%), sensory problems (11.1%), comfort problems (9.3%), donning and doffing problems (7.4%), protection problems (7.4%), wearing product compliance (5.6%), product affordability (3.7%), fabric quality (3.7%), swimwear preference (1.9%), lack of product knowledge (1.9%), body shape (1.9%), mobility problems (1.9%), and construction quality (1.9%). Table 14 features each theme and a sample of participant responses. Response totals for each theme are reported in Figure 51 as a colored pie chart.

Table 14

Participant Sample Responses for Additional Findings

Theme	Additional Findings Responses
Satisfaction with current options	"very satisfied with solar clothing", "is very good", "I'm fully satisfied", and "they satisfy my needs properly"
Swimwear preference	"regular swimwear"
Sensory problems	"delicate skin", "doesn't like the feeling of the fabrics" "wet and sticks to body", "weighing her down", and "sensitive"
Comfort problems	"uncomfortable", "tight" and "sweating"
Fit problems	"it rides up", "fit could be better", "fits weird", "sleeves are narrow", and "waist not adjustable"
Donning and doffing problems	"hard to put on by themselves" and "too much trouble for him"
Product availability	" wish there were more options in my local stores"
Lack of product knowledge	"too new"
Fabric quality	"low quality fabric" and "provide more give"
Product availability	"wish there were more options in my stores" and "need more variety"
Wearing product compliance	"they prefer to not wear it sometimes", "child does not like to keep it on for long", and "teenage girl and doesn't like to wear long sleeves and such"
Body shape	"body type"
Protection problems	"my child needs protection at all times", "protect from UV rays", and "swim shirt somewhat protective but it is not SPF", and "to be helpful"
Product affordability	"cost" and "expensive"
Mobility problems	"child does not feel completely free to move around in them"
Construction quality	"better made"

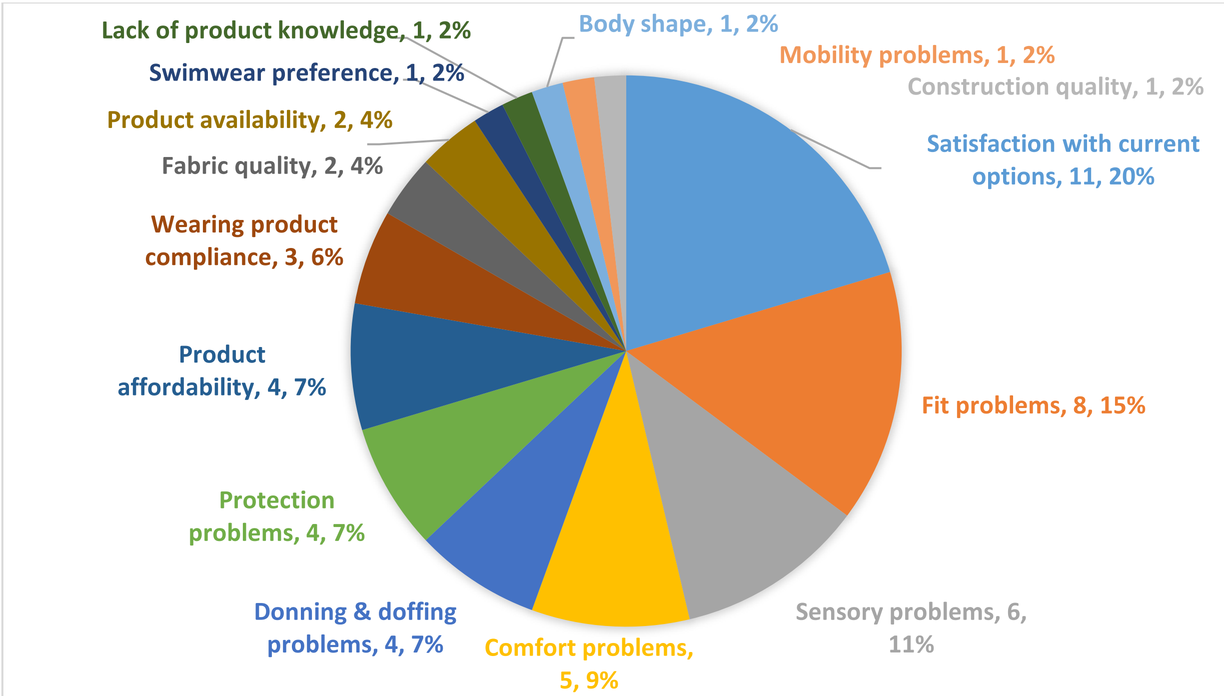


Figure 51. Pie chart showcasing other findings found in additional comments.

Case Study 2 – Wildland Firefighters' Perceptions of

NFPA 1977 Protective Apparel Research Design

Case study 2 applied the proposed Multidimensional Functional Apparel Framework (MFAF) by investigating wildland firefighters' perceptions of their NFPA 1977 Protective Clothing along with any perceived functionality differences between NFPA 1977 editions 2005, 2011, and 2016 apparel. Data were collected through various wildland firefighting organizations, companies, and apprenticeship programs using a hyperlink to an online survey. Participants needed to be at least 19 years of age, living in the United States, and have worn NFRP 1977 Protective Clothing within the last 12 months. A total of 53 individuals were qualified to participate and completed the online survey. The data were exported from Qualtrics into SPSS software for verification that all data were usable. Scale reliabilities for all measures were established. Research questions were analyzed using descriptive statistics, chi-square, and repeated measures ANOVAs. Open-ended responses were coded by two experienced coders using an Excel spreadsheet. The coded data were then imported into SPSS software where inter-coder reliability was established. Each open-ended question was analyzed for frequency distributions. The results section for case study 2 consists of (1) scale reliability, (2) sample demographics, (3) research question analyses, and (4) open-ended question analyses.

Reliability Analysis

Scale reliability for measures were analyzed using Cronbach's *alpha* coefficient for each measure with more than one item. All measures used in the survey had adequate reliability (Cronbach's *alpha* coefficient > .70). Table 15 shows the reliability analysis for each of the study

Table 15

Reliability Analysis of Study Measures

Items	*M*	*SD*	Cronbach's *alpha*	*n*
Fit satisfaction for wildland firefighters' pant			**.87**	53
Waist	2.30	1.40		
Seat	2.70	1.37		
Thigh	2.62	1.42		
Knee	2.66	1.33		
Leg Cuff	3.13	1.91		
Front Rise	3.89	1.72		
Back Rise	3.53	1.88		
Inseam	2.49	1.19		
Fit satisfaction for wildland firefighters' shirt			**.93**	53
Collar Length	2.32	1.09		
Collar Width	2.66	1.19		
Front Length	2.66	1.09		
Back Length	2.98	1.32		
Sleeve Length	3.02	1.20		
Sleeve Cuff	2.81	.98		
Chest	2.81	1.02		
Waist	2.81	1.02		
Bottom	2.75	1.08		

Table 15 Continued

Items	*M*	*SD*	Cronbach's *alpha*	*n*
Performance for wildland firefighters' pant			**.92**	53
Flexible/Stiff	3.02	1.55		
Freedom of/Restrict Movement in Legs	2.72	1.54		
Functional/Not Functional	2.70	1.48		
Loose/Tight	2.91	1.35		
Like/Dislike	2.87	1.49		
Acceptable/Unacceptable	2.74	1.30		
Performance for wildland firefighters' shirt			**.94**	53
Flexible/Stiff	3.00	1.57		
Freedom of/Restrict Movement of Arms	2.79	1.32		
Functional/Not Functional	2.34	1.09		
Loose/Tight	3.04	1.06		
Like/Dislike	3.13	1.67		
Acceptable/Unacceptable	2.94	1.26		
Comfort for wildland firefighters' pant			**.85**	53
Comfortable/Uncomfortable	2.79	1.28		
Cold/Hot	3.87	1.44		
Soft/Harsh to the Skin	3.15	1.55		
Breathable/Does Not Breath	3.83	1.94		
Lightweight/Heavyweight	2.77	1.41		
Non-Irritating/Irritating	2.58	1.45		
Low Static/High Static	2.40	1.29		
Comfort for wildland firefighters' shirt			**.95**	53
Comfortable/Uncomfortable	2.92	1.58		
Cold/Hot	4.02	1.22		
Soft/Harsh to the Skin	3.32	1.60		
Breathable/Does Not Breath	3.77	1.46		
Lightweight/Heavyweight	3.28	1.59		
Non-Irritating/Irritating	3.21	1.57		
Low Static/High Static	3.02	1.38		
Quality for wildland firefighters' pant			**.92**	53
High Quality/Low Quality	3.19	1.65		
Sturdy/Not Sturdy	3.11	1.67		

Table 15 Continued

Items	*M*	*SD*	Cronbach's *alpha*	*n*
Quality for wildland firefighters' shirt			**.82**	53
High Quality/Low Quality	2.79	1.06		
Sturdy/Not Sturdy	2.66	1.21		
Ease of Care for wildland firefighters' pant			**.86**	53
Ease Care/Not Easy to Care	2.23	1.33		
Machine Washable/Not Machine Washable	2.21	1.41		
Ease of Care for wildland firefighters' shirt			**.88**	53
Ease Care/Not Easy to Care	2.09	1.08		
Machine Washable/Not Machine Washable	2.11	1.01		

Based on a 7-point semantic scale.

measures with mean, standard deviation, Cronbach's alpha, and sample size.

Open-ended questions were analyzed using the same content analysis procedures as described in case study 1. Coding sheets with a code, category, and description were developed by the researcher by analyzing qualitative text received from the participants. A separate coding sheet was made for each of the eight open-ended questions. The first open-ended question, "If you could change the fit of the pant, what would you change?" had 15 themes: (a) waist fit changes, (b) crotch fit changes, (c) knee fit changes, (d) style changes, (e) durability problems, (f) mobility fit changes, (g) back rise fit changes, (h) front rise fit changes, (i) pocket size changes, (j) seat fit changes, (k) hip fit changes, (l) inseam fit changes, (m) labeling problems, (n) leg cuff fit changes, and (o) thigh fit changes (see Table 16).

Table 16

Coding Sheet for Change of Pant Fit

Theme #	Theme Label	Definition of Theme	Example Comments for Theme
1	Waist Fit Changes	Comment about a desired change or problem with waist fit	“loose waist” or “adjustable waist”
2	Crotch Fit Changes	Comment about a desired change or problem with crotch fit	“too high of a crotch” or “tight crotch”
3	Knee Fit Changes	Comment about a desired change or problem with knee fit	“reinforce knee” or “knees bind”
4	Style Changes	Comment about a desired change or problem with the style	“too baggy” or “tight”
5	Durability Problems	Comment about a desired change or problem with durability	“easily ripped” or “doesn’t last”
6	Mobility Fit Changes	Comment about a desired change or problem with mobility fit	“can’t move” or “stop my movement”
7	Back Rise Fit Changes	Comment about a desired change or problem with back rise fit	“rises in back” or “too long of a back rise”
8	Front Rise Fit Changes	Comment about a desired change or problem with front rise fit	“front rise is too short” or “front rise is long”
9	Pocket Size Changes	Comment about a desired change or problem with pocket size	“pocket too small” or “items fall out of pocket”
10	Seat Fit Changes	Comment about a desired change or problem with seat fit	“seat rises” or “seat sags”
11	Hip Fit Changes	Comment about a desired change or problem with hip fit	“hip tight” or “hips too large for me”
12	Inseam Fit Changes	Comment about a desired change or problem with inseam fit	“not long enough pant leg” or “need more inseam options”
13	Labeling Problems	Comment about a desired change or problem with labeling	“can’t read label” or “label rubs”

Table 16 Continued

Theme #	Theme Label	Definition of Theme	Example Comments for Theme
14	Leg Cuff Fit Changes	Comment about a desired change or problem with leg cuff fit	"leg cuff too large" or "debris goes up leg cuff"
15	Thigh Fit Changes	Comment about a desired change or problem with thigh fit	"thigh too tight when bending" or "seam at thigh rips"

The second open-ended question, "If you could change or improve the comfort of your pant, what would offer you more comfort?" had 14 themes: (a) component changes, (b) crotch changes, (c) durability changes, (d) fabric changes, (e) front rise changes, (f) hip changes, (g) knee changes, (h) leg cuff changes, (i) mobility changes, (j) pant length changes, (k) pocket size changes, (l) style changes, (m) thigh changes, and (n) back rise changes (see Table 17).

Table 17

Coding Sheet for Change of Pant Comfort

Theme #	Theme Label	Definition of Theme	Example Comments for Theme
1	Component Changes	Comment about a desired change or problem with the component comfort	"gusset too small" or "remove pocket flaps"
2	Crotch Changes	Comment about a desired change or problem with crotch comfort	"tight crotch" or "crotch rises"
3	Durability Changes	Comment about a desired change or problem with durability	"seams rip" or "doesn't last as long"
4	Fabric Changes	Comment about a desired change or problem with the fabric comfort	"less chafing" or "itchy"

Table 17 Continued

Theme #	Theme Label	Definition of Theme	Example Comments for Theme
5	Front Rise Changes	Comment about a desired change or problem with front rise comfort	"front rise uncomfortable" or "rises in front and hurts"
6	Hip Changes	Comment about a desired change or problem with hip comfort	"hips area rubs" or "roomier hips"
7	Knee Changes	Comment about a desired change or problem with knee comfort	"knees rubs when bending" or "knees bind uncomfortably"
8	Leg Cuff Changes	Comment about a desired change or problem with leg cuff comfort	"cuff rubs" or "leg cuff gets caught when walking"
9	Mobility Changes	Comment about a desired change or problem with mobility comfort	"can't move comfortable" or "uncomfortable when kneeling"
10	Pant Length Changes	Comment about a desired change or problem with the pant length comfort	"too long" or "too short"
11	Pocket Size Changes	Comment about a desired change or problem with pocket comfort	"hand doesn't fit in pocket" or "pocket rubs"
12	Style Changes	Comment about a desired change or problem with the style comfort	"tight style uncomfortable" or "loose pant catches on debris"
13	Thigh Changes	Comment about a desired change or problem with thigh comfort	"thighs cut into legs when bending" or "thighs rub"
14	Back Rise Changes	Comment about a desired change or problem with back rise comfort	"raise the back" or "back rise uncomfortable"

The third open-ended question, "Explain any of the pant protection problems that you selected above, if applicable." had 3 themes for protection problems: (a) leg cuff protection problems, (b) thigh protection problems, and (c) knee protection problems (see Table 18).

Table 18

Coding Sheet for Change of Pant Protection

Theme #	Theme Label	Definition of Theme	Example Comments for Theme
1	Leg Cuff Protection Problems	Comments were associated with pant leg cuff protection	"smaller leg cuff" or "cuff allows heat to enter pant"
2	Thigh Protection Problems	Comments were associated with thigh protection	"thigh area becomes worn through" or "thigh seam rips"
3	Knee Protection Problems	Comments were associated with knee protection	"reinforced knee needed" or "knees become worn too fast"

The fourth open-ended question, "If you could change the fit of the shirt, what would you change?" had 12 themes: (a) shoulder fit changes, (b) chest fit changes, (c) cuff fit changes, (d) sleeve length fit changes, (e) style changes, (f) back length fit changes, (g) closures changes, (h) shirt bottom width fit changes, (i) collar fit changes, (j) durability changes, (k) elbow fit changes, and (l) waist fit changes (see Table 19).

Table 19

Coding Sheet for Change of Shirt Fit

Theme #	Theme Label	Definition of Theme	Example Comments for Theme
1	Shoulder Fit Changes	Comment about a desired change or problem with shoulder fit	"shoulders too small" or "shoulder do not fit properly"
2	Chest Fit Changes	Comment about a desired change or problem with chest fit	"tight chest" or "chest not large enough"
3	Cuff Fit Changes	Comment about a desired change or problem with cuff fit	"cuffs too big" or "cuff too wide"

Table 19 Continued

Theme #	Theme Label	Definition of Theme	Example Comments for Theme
4	Sleeve Length Fit Changes	Comment about a desired change or problem with sleeve length fit	“longer sleeve length” or “sleeves too short”
5	Style Changes	Comment about a desired change or problem with style fit	“don’t like the style” or “quit changing the styles”
6	Back Length Fit Changes	Comment about a desired change or problem with back length fit	“back of shirt comes out of pant” or “back of shirt too long”
7	Closures Changes	Comment about a desired change or problem with closures	“no Velcro™” or “buttons crack”
8	Shirt Bottom Width Fit Changes	Comment about a desired change or problem with shirt bottom width fit	“a more tapered bottom hem” or “shirt bottom too wide”
9	Collar Fit Changes	Comment about a desired change or problem with collar fit	“collars too wide” or “collar too tight”
10	Durability Changes	Comment about a desired change or problem with durability	“gets holes easily” or “rips after a year”
11	Elbow Fit Changes	Comment about a desired change or problem with elbow fit	“elbow binds” or “elbow area too big”
12	Waist Fit Changes	Comment about a desired change or problem with waist fit	“waist too large” or “waist billows out of pant”

The fifth open-ended question, “If you could change or improve the comfort of your shirt, what would offer you more comfort?” had 11 themes: (a) back length changes, (b) chest changes, (c) closure changes, (d) collar changes, (e) component changes, (f) equipment interaction changes, (g) fabric changes, (h) shoulder changes, (i) sleeve changes, (j) style changes, and (k) wearable technology changes (see Table 20).

Table 20

Coding Sheet for Change of Shirt Comfort

Theme #	Theme Label	Definition of Theme	Example Comments for Theme
1	Back Length Changes	Comment about a desired change or problem with back length comfort	“back too long” or “shirt back comes untucked”
2	Chest Changes	Comment about a desired change or problem with chest comfort	“chest uncomfortable” or “chest tight”
3	Closure Changes	Comment about a desired change or problem with closure comfort	“Velcro™ is itchy” or “zippers get hot”
4	Collar Changes	Comment about a desired change or problem with collar comfort	“shorter collar” or “collar rubs”
5	Component Changes	Comment about a desired change or problem with component comfort	“reinforced shoulder needed” or “knee reinforcement needed”
6	Equipment Interaction Changes	Comment about a desired change or problem with equipment interactions	“chain saw rips shoulder” or “radio is hard to get out of pocket”
7	Fabric Changes	Comment about a desired change or problem with fabric comfort	“cuff is rough to skin” or “chafing”
8	Shoulder Changes	Comment about a desired change or problem with shoulder comfort	“shoulders too tight” or “shoulders too large”
9	Sleeve Changes	Comment about a desired change or problem with sleeve comfort	“sleeve binds” or “sleeve too short”
10	Style Changes	Comment about a desired change or problem with style comfort	“very baggy” or “needs to be more fitted”
11	Wearable Technology Changes	Comment about a desired change or problem with wearable technology	“need cooling feature” or “technology doesn’t work”

The sixth open-ended question, “Explain any of the shirt protection problems that you selected above, if applicable.” had 4 themes: (a) shoulder protection problems, (b) collar protection problems, (c) back length protection problems, and (d) sleeve length protection problems (see Table 21).

Table 21

Coding Sheet for Change of Shirt Protection

Theme #	Theme Label	Definition of Theme	Example Comments for Theme
1	Shoulder Protection Problems	Comment about a desired change or problem with shoulder protection	"reinforced shoulders needed" or "knee reinforcement needed"
2	Collar Protection Problems	Comment about a desired change or problem with collar protection	"collar is irritating" or "collar doesn't protection from heat"
3	Back Length Protection Problems	Comment about a desired change or problem with back length protection	"longer shirt tails" or "shirt tails too long"
4	Sleeve Length Protection Problems	Comment about a desired change or problem with sleeve length protection	"longer sleeves" or "sleeves too short and don't protect"

The seventh open-ended question, "Have you ever experienced your equipment causing problems with your movement, comfort, protection, fit, durability, or so on while working in your firefighting apparel? Please explain in detail what problems you experienced." had 7 themes: (a) fit interaction problems, (b) mobility interaction problems, (c) components interaction problems, (d) closures interaction problems, (e) comfort interaction problems, (f) quality interaction problems, and (g) durability problems (see Table 22).

Table 22

Coding Sheet for Changes Needed Due to Equipment Interaction

Theme #	Theme Label	Definition of Theme	Example Comments for Theme
1	Fit Interaction Problems	Comments about equipment causing fit problems	“cargo pockets can affect fit” or “radio makes chest tight”
2	Mobility Interaction Problems	Comments about equipment causing mobility problems	“hard to move properly with pack” or “radio gets in the way of the pack straps”
3	Components Interaction Problems	Comments about equipment causing component problems	“radio chest pocket is always in the way” or “pocket flaps a nuisance”
4	Closures Interaction Problems	Comments about equipment causing closure problems	“Velcro™ catches on equipment” or “no buttons on pockets”
5	Comfort Interaction Problems	Comments about equipment causing comfort problems	“radio rubs uncomfortably” or “chain saw cuts shoulders”
6	Quality Interaction Problems	Comments about equipment causing quality problems	“chainsaw cuts fabric” or “radio pocket gets ripped”
7	Durability Problems	Comments about equipment causing durability problems	“equipment gets caught on fabric” or “equipment rubbed a hole in fabric”

The eighth open-ended question, “Is there any additional information we should know about how your firefighting apparel could be improved?” had 10 themes: (a) component changes, (b) closure changes, (c) durability issues, (d) affordability issues, (e) fabric changes, (f) inseam changes, (g) pocket size changes, (h) repair kit recommendation, (i) seat changes, and (j) style changes (see Table 23).

Table 23

Coding Sheet for Additional Information on Firefighting Apparel Improvements

Theme #	Theme Label	Definition of Theme	Example Comments for Theme
1	Component Changes	Comments about component changes	"belt loops could be longer", or "more vents"
2	Closure Changes	Comments about closure changes	"no Velcro™" or "better snaps"
3	Durability Issues	Comments about durability issues	"collar fraying" or "cuffs torn"
4	Affordability Issues	Comments about affordability issues	"overpriced" or "can't afford new apparel"
5	Fabric Changes	Comments about fabric changes	"holes" or "fraying"
6	Inseam Changes	Comments about inseam changes	"inseam too short" or "more inseam options"
7	Pocket Size Changes	Comments about pocket size changes	"move radio pocket" or "need cargo pockets"
8	Repair Kit Recommendation	Comments about repair kit recommendation	"a repair kit would be nice", or "ability to repair seam in field"
9	Seat Changes	Comments about seat changes	"seat too tight" or "seat sags"
10	Style Changes	Comments about style changes	"too baggy" or "need a fitted style"

Intercoder reliability was established for the open-ended questions by cross tabulating each of the coders results and are reported in the Table 24 with the Kappa statistic, number of themes, and number of valid cases.

Table 24

Intercoder reliability of coded Open-ended Questions

Question	Kappa	N of Themes	N of Valid Cases
If you could change the fit of the pant, what would you change?	.95	15	45
If you could change or improve the comfort of your pant, what would offer you more comfort?	.79	14	31
Explain any of the pant protection problems that you selected above, if applicable.	1.00	3	4
If you could change the fit of the shirt, what would you change?	.92	12	27
If you could change or improve the comfort of your shirt, what would offer you more comfort?	.84	12	21
Explain any of the shirt protection problems that you selected above, if applicable.	1.00	4	11
Have you ever experienced your equipment causing problems with your movement, comfort, protection, fit, durability, or so on while working in your firefighting apparel. Please explain in detail what problems you experienced.	.91	7	14
Is there any additional information we should know about how your firefighting apparel could be improved.	1.00	10	14

Sample Demographics

The sample consisted of 53 participants, who all wore wildland firefighting apparel that met the NFPA 1977 regulations and had a vast range of experience from 2 to more than 50 years. The participants consisted of 49 males (92.5%) and 4 females (7.5%), with an age range from 19 to over 65 years of age. Participants were mostly married (47.2%), Caucasian (88.7%) and had an annual family income of $60,000-$69,000 (39.6%). All participants were from the Northwest and represented five different states. Table 25 reports the frequencies and percentages associated with participant gender, age, residence, marital status, ethnicity, and family income.

Table 25

Case Study 2 - Characteristics of Sample

Demographic Characteristic	Frequency *(n=53)*	Percentage
Apparel meet NFPA 1977 regulation		
Yes	**53**	**100%**
No	0	0%
Gender		
Male	**49**	**92.5%**
Female	4	7.5%
Age		
19-24	1	1.9%
25-34	19	35.8%
35-44	**25**	**47.2%**
45-54	0	0.0%
55-64	2	3.8%
65 and above	6	11.3%
Experience in Years		
Over 1-5	10	18.9%
6-10	14	26.4%
11-15	8	15.1%
16-19	6	11.3%
Over 20	**15**	**28.3%**
Residence		
Washington	**15**	**28.3%**
Oregon	14	26.4%
California	13	24.5%
Idaho	8	15.1%
Nevada	3	5.7%
Marital Status		
Never married	11	20.8%
Married	**25**	**47.2%**
Widowed	1	1.9%
Divorced	16	30.2%
Ethnicity		
Caucasian	**47**	**88.7%**
Hispanic	4	7.5%
American Indian/Alaska Native	2	3.8%
Family Income		
$20,000-$29,999	5	9.4%
$30,000-$39,999	6	11.3%
$40,000-$49,999	4	7.5%
$50,000-$59,999	5	9.4%
$60,000-$69,999	**21**	**39.6%**

Table 25 Continued

Demographic Characteristic	Frequency *(n=53)*	Percentage
$70,000-$79,9999	2	3.8
$80,000-$89,999	0	0.0%
$90,000-$99,000	3	5.7%
$100,000 and above	7	13.2%

Research Question Analysis

Research Question 1. What are wildland firefighters' perceptions of their NFPA 1977 Protective Clothing based on the *end-user dimension* of the Multidimensional Functional Apparel Framework (MFAF): (a) affordability.

Affordability. Descriptive statistics revealed affordability for the wildland firefighter apparel had a mean of 2.32 with a standard deviation of 1.05, indicating participants felt that the affordability of the wildland firefighters pant and shirt was very good.

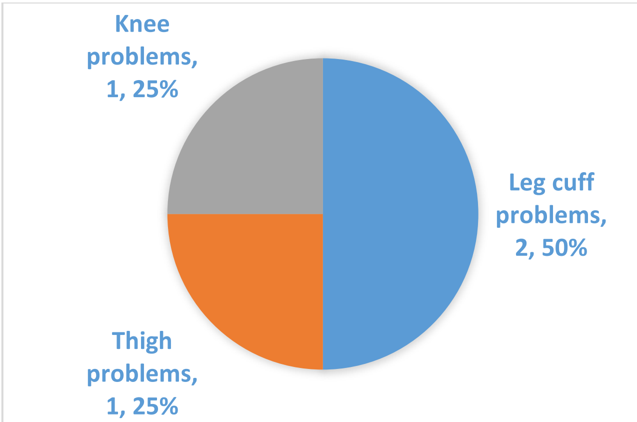
Research Question 2. What are wildland firefighters' perceptions of their NFPA 1977 Protective Clothing based on the *task dimension* of the Multidimensional Functional Apparel Framework (MFAF); (a) protection, (b) NFPA 1977 regulations and (c) equipment interactions.

Protection. Problematic areas for protection in the wildland firefights' pant and shirt were reported in two open-ended questions. The open-ended question "Explain any of the pant protection problems that you selected above, if applicable." revealed 3 themes from 4 responses, which were (a) leg cuff protection problems, (b) thigh protection problems, and (c) knee protection problems. The second open-ended question "Explain any of the shirt pro=tection problems that you selected above, if applicable." revealed 4 themes from 11 responses: (a) shoulder protection problems, (b) collar protection problems, (c) back length protection problems, and (d) sleeve length protection problems. Table 26 features each theme and a sample of participant response recommendations. Participant comments associated with the leg cuff accounted for 50% of the pant protection problem responses, while shoulders protection problems accounted for 37% of the shirt protection problem responses. Response totals and percentages for each theme are reported in Figure 52 as a colored pie chart.

Table 26

Participant Sample Responses for Protection Problems in Wildland Firefighters' Apparel

Theme	Protection Problematic Area Responses
Leg cuff protection problems	"leg cuff on pants wear through… primary pant and had them for 5 years" and "smaller leg cuff"
Thigh protection problems	"thigh wears through"
Knee protection problems	"needs reinforced knee"
Shoulder protection problems	"add another layer of fabric to the shoulders to prevent saw teeth cuts", "shoulder area of some shirts wear out quickly due to pack", "we carry all sorts of things into the fires we hike into at times and over the shoulder is the best method sometimes, and chain saws do the most damage by cutting the materials leaving an opening", and "top of shoulder stitching becomes an issue because of rub points on field packs (line gear)"
Collar protection problems	"collar is irritating with the Velcro™ and useless", "collar doesn't stay out of the way", and "collars on 2000 era shirts not great for protection from debris … newer Velcro™ collars are better, more adjustable"
Back length protection problems	"larger or taller people can have trouble keeping the flat bottom tucked in. The French tail can make it easier for those people", "Longer tails stay in while bent over", and "another firefighter's shirt was swallow tail and kept coming untucked"
Sleeve length protection problems	"longer sleeves to cover under your gloves when arms bent"



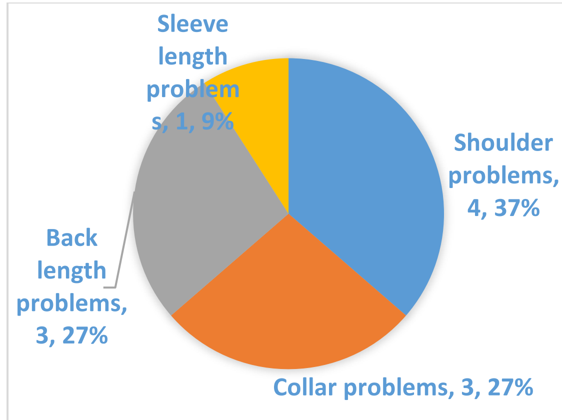


Figure 52. Pie chart featuring problematic protection areas reported in wildland firefighters' apparel.

NFPA 1977 Regulations. With respect to regulations (RQ2b), descriptive statistics revealed regulations of the NFPA 1977 2016 edition pants were the most used (47.1%) while 2005 edition shirts were the most used (49.1%). Table 27 reports the category by edition including each frequency and percentage.

Table 27

Regulations: Editions of NFPA 1977 Protective Apparel (n=53)

Apparel Category	2005 edition		2011 edition		2016 edition	
	n	%	*n*	%	*n*	%
Pant	18	34.0%	10	18.9%	**25**	**47.1%**
Shirt	**26**	**49.1%**	17	32.1%	10	18.8%

Equipment interactions. To assess equipment interactions (RQ2c), the following open-ended question was used: "Have you ever experienced your equipment causing problems with your movement, comfort, protection, fit, durability, or so on while working in your firefighting apparel? Please explain in detail what problems you experienced." There were 19 participant responses that revealed 7 different themes for equipment interactions: (a) fit interaction problems, (b) mobility interaction problems, (c) components interaction problems, (d) closures interaction problems, (e) comfort interaction problems, (f) quality interaction problems, and (g) durability problems. Table 17 features each theme and a sample of participant responses for equipment interaction problems. Comments were mostly associated with fit interaction problems (32%), followed by mobility interaction problems (16%) and components interaction problems (16%). Response totals and percentages for each equipment interaction theme are reported in Figure 53 as a colored pie chart.

Table 17

Participant Sample Responses for Equipment Interaction Problems in Wildland Firefighting Apparel

Theme	Equipment Interaction Responses
Fit problems	"pants never fit properly", "do not fit women", "sometimes equipment hangs up or gets caught in extra fabric at waist and wrists", "belt loops too small", and "collars on the new Nomex get in the way"
Quality problems	"crotch rip on multiple pairs" and "inner pant cuffs always blowout"
Mobility problems	"problems with knees binding while working with hand tools or climbing on engine" and "ease of movement in pants"
Closure problems	"Velcro™ pocket closures are a very good thing"
Components problems	"Nomex pant cargo pockets are too small", "using cargo pockets affects fit", and "radio chest pack is always in the way"
Durability problems	"pack rubs on top of shoulder stitching"
Comfort problems	"pants get warm" and "Velcro™ collars are irritating"

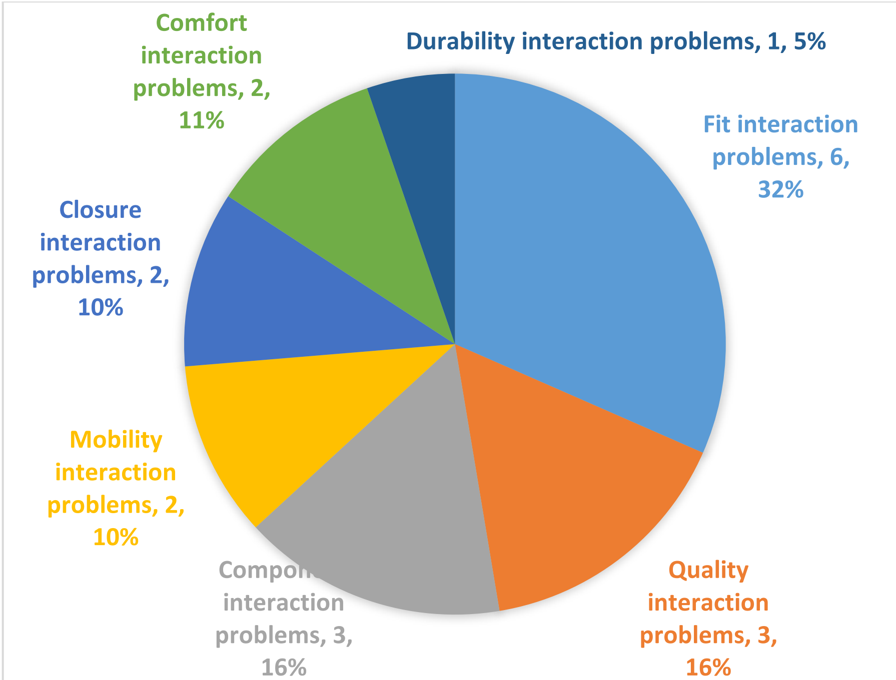


Figure 53. Pie chart showcasing equipment interaction problems with wildland firefighters apparel.

Research Question 3. What are wildland firefighters' perceptions of their NFPA 1977 Protective Clothing based on the design dimension of the Multidimensional Functional Apparel Framework (MFAF): (a) fit, (b) body shape, (c) mobility, (d) comfort, (e) durability, (f) performance, (g) donning and doffing ease, (h) components and (i) closures.

Fit. Pant fit was analyzed with repeated-measures ANOVA with eight levels (apparel areas) assessing fit satisfaction. The means and standard deviations for pant fit satisfaction in each of the 8 apparel areas are presented in Table 29. The results for the ANOVA indicated that there was a statistically significant difference with pant fit satisfaction across the different areas, Wilks' Lambda = 0.50, $F(1,52) = 11.33$, $p < .000$, multivariate η2 = .25. Post hoc analyses were conducted given the statistically significant ANOVA result. Tukey HSD post hoc tests were conducted on all possible pairwise comparisons using the Bonferroni correction. Eight pairs were

Table 29

Means and Standard Deviations for Pant Fit Satisfaction Assessment Areas

Fit Dimensions	*n*	*M*	*SD*
Waist	53	2.30	1.30
Seat	53	2.70	1.37
Thigh	53	2.62	1.42
Knee	53	2.66	1.33
Leg cuff	53	3.13	1.91
Front rise	53	3.89	1.72
Back rise	53	3.53	1.88
Inseam	53	2.49	1.19

Note: Based on 7-point Likert scale (1=Extremely satisfied; 7=Extremely dissatisfied).

found to be significantly different ($p < .05$): front rise was found to have a significantly lower satisfaction level than waist, seat, thigh, knee, and inseam, and the back rise also had a significantly lower satisfaction level than waist and inseam.

Shirt fit was analyzed with repeated-measures ANOVA with nine levels (apparel areas) assessing fit satisfaction. The means and standard deviations for shirt fit satisfaction in each of the nine apparel areas are presented in Table 30. The results for the ANOVA indicated there was

Table 30

Means and Standard Deviations for Shirt Fit Satisfaction Assessment Areas

Fit Dimensions	*n*	*M*	*SD*
Collar length	53	2.32	1.09
Collar width	53	2.66	1.19
Front length	53	2.66	1.09
Back length	53	1.98	1.32
Sleeve length	53	3.02	1.20
Sleeve cuff	53	2.81	.98
Chest	53	2.81	1.02
Waist	53	2.81	1.02
Bottom	53	2.75	1.07

Note: Based on 7-point Likert scale (1=Extremely satisfied; 7=Extremely dissatisfied).

a statistically significant difference with the shirt fit satisfaction effect, Wilks' Lambda = 0.56, $F(8,416) = 4.27$, $p < .000$. Post hoc analyses were conducted given the statistically significant ANOVA test. Tukey HSD post hoc tests were conducted on all possible pairwise comparisons using the Bonferroni correction. One pair was found to be significantly different ($p < .05$): collar length was found to have a significantly greater satisfaction level than sleeve length.

Additionally, two open-ended questions, "If you could change the fit of the pant, what would you change?" and "If you could change the fit of the shirt, what would you change?" were asked of the participants. Forty-five responses for the pant fit open-ended question revealed 15 different themes; (a) waist fit changes, (b) crotch fit changes, (c) knee fit changes, (d) style changes, (e) durability problems, (f) mobility fit changes, (g) back rise fit changes, (h) front rise fit changes, (i) pocket size changes, (j) seat fit changes, (k) hip fit changes, (l) inseam fit changes, (m) labeling problems, (n) leg cuff fit changes, and (o) thigh fit changes. Table 31 features the themes and a sample of participant responses for pant fit changes or problems.

Table 31

Participant Sample Responses for Pant Fit Changes

Theme	Pant Fit Change Responses
Waist fit changes	"too small in the waist", "user friendly waist adjusters", and "correct waist often has the wrong amount of give"
Crotch fit changes	"tight in the crotch", more reinforcement in crotch", and "better fit in crotch"
Knee fit changes	"knee", "reinforce knee", "better fit in knee", and "knee location in wrong place for me"
Style changes	"exceptionally baggy", "like Kevlar models", "fitted type of pants", "newer styles", and "provides men's pants … but I'm a woman"
Durability problems	"rips easily", "worn", and "rips happen"
Mobility fit changes	"more movement" and "restricting movement"
Back rise fit changes	"shorter back rise", "raise the back", and "back rise too small… seems like it's a thong at times"

Table 31 Continued

Theme	Pant Fit Change Responses
Front rise fit changes	"front rise shorter", "not rise so high at waist", and "looseness at front rise"
Pocket size changes	"put anything in the cargo pocket and it makes it too tight", "bigger cargo pockets", and "size doesn't allow for fire wallet to fit in comfortably"
Seat fit changes	"smaller butt"
Hips fit changes	"more room in hips"
Inseam fit changes	"correct inseam"
Labeling problems	"tags are unreadable"
Leg cuff fit changes	"taper leg to reduce ash up leg"
Thigh fit changes	"little wider in the thigh"

Comments associated with the waist accounted for 13% of the pant fit changes or problems and the crotch, knee, and style comments accounted for 11% each. Response totals and percentages for pant fit change or problem themes are reported in Figure 54 as a colored pie chart.

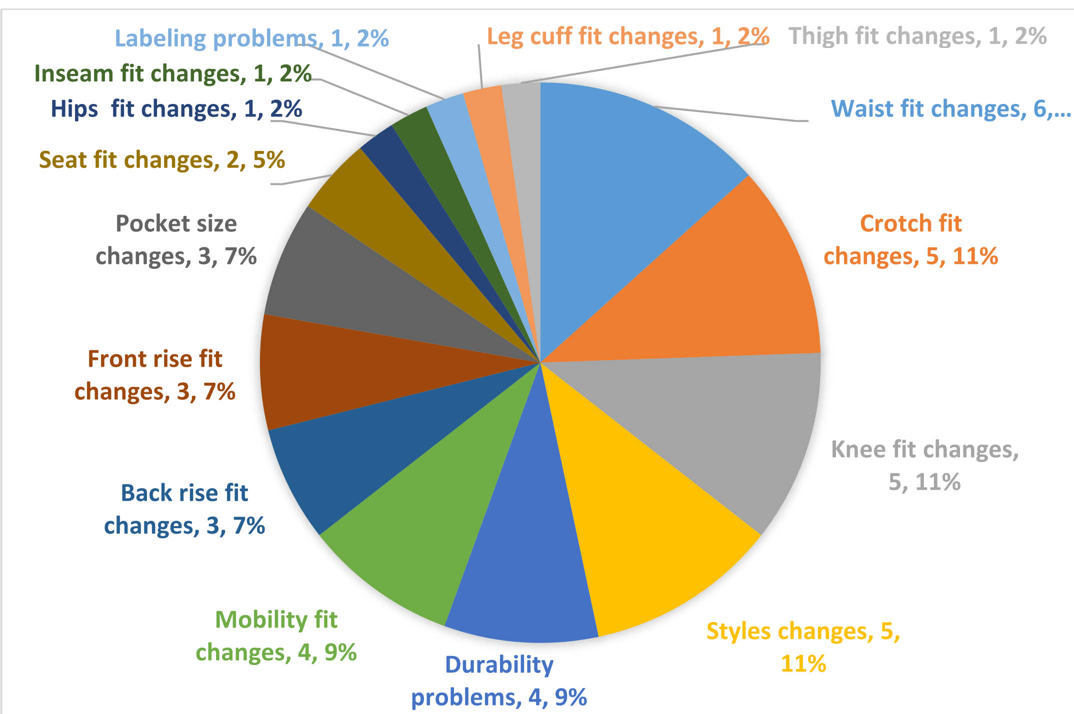


Figure 54. Pie chart showcasing pant fit change themes with wildland firefighters.

Twelve themes were revealed for the changes to shirt fit open-ended question based on a total of 27 responses; (a) shoulder fit changes, (b) chest fit changes, (c) cuff fit changes, (d) sleeve length fit changes, (e) style changes, (f) back length fit changes, (g) closures changes, (h) shirt bottom width fit changes, (i) collar fit changes, (j) durability changes, (k) elbow fit changes, and (l) waist fit changes. Table 32 features the themes and a sample of participant responses for their recommended shirt fit changes.

Table 32

Participant Sample Responses for Shirt Fit Changes

Theme	Shirt Fit Change Responses
Shoulder fit changes	"shoulders", "more room in the shoulders", and "more taper between the arms"
Chest fit changes	"more fabric in front, less in back", "chest tight on my body", and "needs to accommodate my bust"
Cuff fit changes	"cuffs are a little too big"
Sleeve length fit changes	"more accurate sleeve length", "sleeves a little bit long", "and "longer sleeve length would be nice"
Style fit changes	"as a woman, these shirts aren't cut for me", "wearing a shirt that is baggy", and "woman's shirt please"
Back length fit changes	"long length in back", and "longer shirt, we bend over and it comes untucked a lot"
Closures changes	"Velcro™ not long enough", "no Velcro™", and "zipper option"
Collar fit changes	"front of collar"
Bottom width fit changes	"extra folds of fabric and issue with the fit of pack", and "more taper at bottom hem"
Durability changes	"extra layer of fabric"
Elbow fit changes	"reinforce elbows"
Waist fit changes	"waist is tight for my body"

Comments associated with the shoulders accounted for 15% of the shirt fit change recommendations by the participants, followed by chest, cuff, sleeve length, and styles, each at 11%. Response totals and percentages for shirt fit themes are reported in Figure 55 as a colored pie chart.

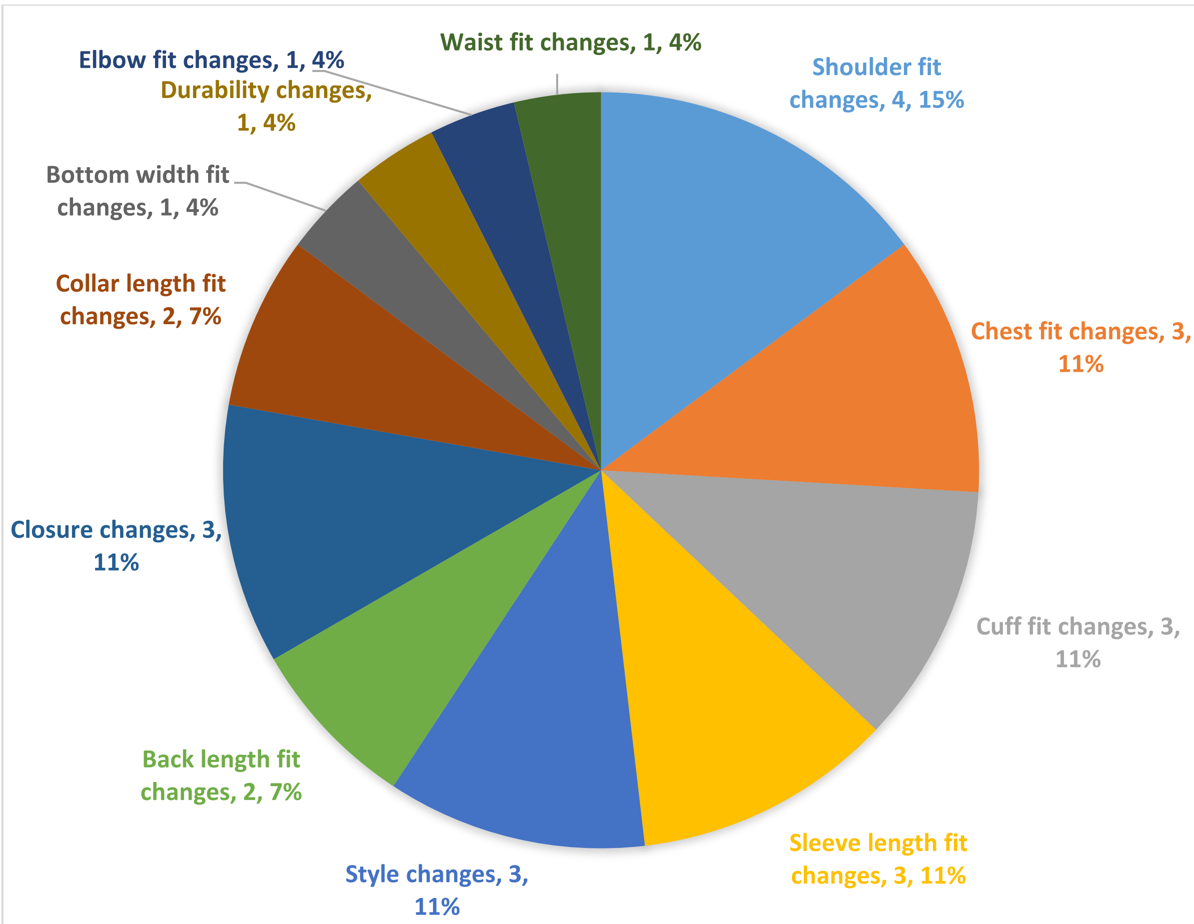
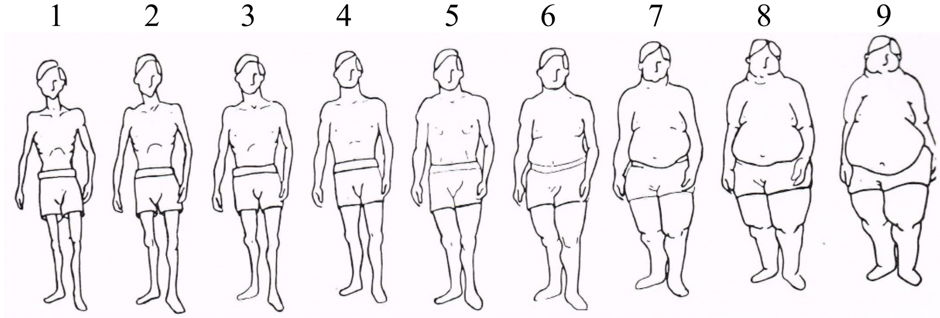
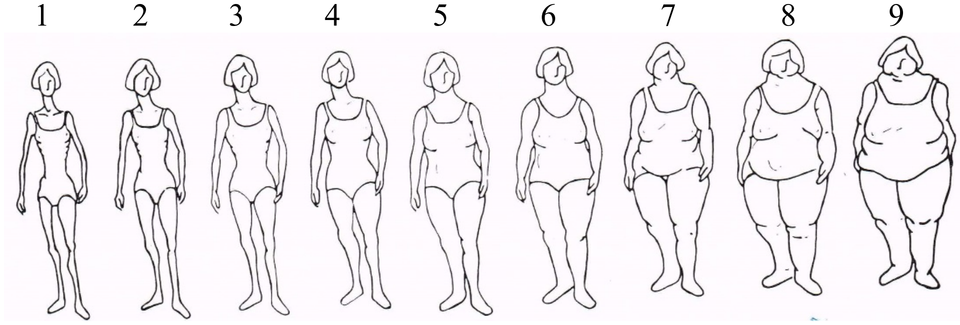


Figure 55. Pie chart showcasing shirt fit change themes with wildland firefighters apparel.

Body shape. Descriptive statistics revealed that majority male body shape was silhouette image 5 (34.7%) while the female body shape majority silhouette image was 4 (100%) (Table 33). Most of the male sample and all of the female sample saw themselves in the middle range of the body shape scale. A small portion of the male sample (18.4%) saw themselves as underweight or thin (see image 3 in Table 33); 18.5% saw themselves as slightly overweight (see image 6 in Table 33); and 6.1% saw themselves as overweight (see images 7 in Table 33). Table 33 features all of the body shape silhouettes by gender with the frequency and percentage of responses to aid in a visualization of the body shape seen by the participants.

Table 33

Wildland Firefighters' Body Shape Silhouette Perception by Gender, Frequency, and Percentage

Gender	*n*	Image								
		1	2	3	4	5	6	7	8	9
										
Male	49			9 18.4%	11 22.4%	**17** **34.7%**	9 18.5%	3 6.1%		
		1	2	3	4	5	6	7	8	9
										
Female	4				**4** **100.0%**					

Mobility. Descriptive statistics revealed mobility in the legs of wildland firefighters pants had a mean of 2.72 with a standard deviation of 1.52 (7-point bipolar adjective; freedom of movement in legs to restrict movement in legs) and the mobility in the arms of wildland firefighters shirts had a mean of 2.79 with a standard deviation of 1.32 (freedom of movement in arms to restrict movement in arms). This indicates participants felt that mobility in the wildland firefighters' pant and shirt was mostly good. Descriptive statistics of the mobility problems based on technical sketches found that there were more reported problems with the pants, a total of 31, compared to only 6 for the shirt. The most problematic areas of the pant were the front crotch (25.8%) and front rise (22.6%), while the most problematic areas of the shirt were the chest (33.3%) and sleeve length (33.3%). Table 34 indicates all the chosen mobility problem areas of the pant and shirt along with the frequency and percentages.

Table 34

Frequency and Percentages of Mobility Problematic Areas of Pants and Shirt

Problematic Areas	Frequency	%
Pant	31	
Front Crotch	**8**	**25.8%**
Front Rise	7	22.6%
Front Seat	3	9.7%
Front Knees	3	9.7%
Back Crotch	3	9.7%
Back Rise	2	6.4%
Buttocks	2	6.4%
Front Ankle	1	3.2%
Back Calf	1	3.2%
Inseam	1	3.2%
Shirt	6	
Chest	**2**	**33.3%**
Sleeve Length	**2**	**33.3%**
Shoulders	1	16.7%
Waist	1	16.7%

Note: A technical pant and shirt sketch was shown to participants which allowed them to click on the apparel area, such as the pant inseam or shirt chest, to report it as a mobility problematic area.

Comfort. Descriptive statistics revealed that the participants' perceptions of the overall comfort for the wildland firefighters pant and shirt were good, see Figure 56. Additionally, a one-sample *t*-test was performed to investigate if participants' perceptions of pant and shirt comfort were different. A statistically significant difference was found between the pant and shirt for lightweight to heavyweight, non-irritating to irritating and low static to high static. Compared to the shirt the pant was perceived as more lightweight, $t(52) = -2.781$, p = .008, less irritating, $t(52) = -3.648$, p = .001, and having lower static level, $t(52) = -3.517$, p = .001 (Figure 56).

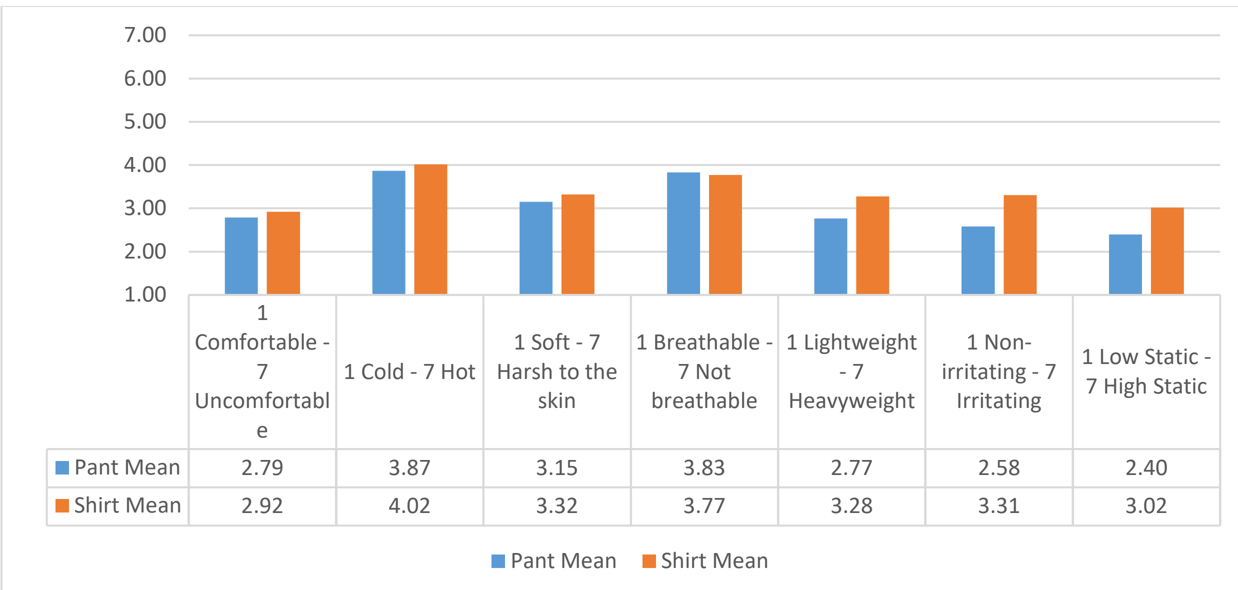


Figure 56. Comfort measures for wildland firefighters pant and shirt.

Two open-ended questions, "If you could change the comfort of the pant, what would offer you more comfort? Explain in detail." and "If you could change the comfort of the shirt, what would offer you more comfort? Explain in detail." were asked of the participants. They gave 31 different responses that represented 14 themes of pant comfort changes: (a) component changes, (b) crotch changes, (c) durability changes, (d) fabric changes, (e) front rise changes, (f) hip changes, (g) knee changes, (h) leg cuff changes, (i) mobility changes, (j) pant length changes,

(k) pocket size changes, (l) style changes, (m) thigh changes, and (n) back rise changes. Table 35 features the pant comfort themes and a sample of the participant responses on pant comfort changes. Comments associated with knee changes accounted for 16% of the pant comfort problems, followed by back rise, crotch, and mobility changes at 10% each. Response totals and percentages for pant comfort change themes are reported in Figure 57 as a colored pie chart.

Table 35

Participant Sample Responses for Pant Comfort Problems

Theme	Pant Comfort Responses
Knee changes	"knee", "knee bend", and "tight at knees when kneeling"
Style changes	"wider legs", "looser", and "good cotton jeans"
Back rise changes	"back rise", "raise the back" and "rise too long and I'm often pulling up my pants"
Crotch changes	"more room in crotch" and "improve room in groin"
Durability changes	"fraying" and "reinforced stitching"
Mobility changes	"bending" and "movements"
Pocket size changes	"larger pockets"
Component changes	"pocket for fire wallet"
Fabric changes	"thinner and softer material"
Front rise changes	"front rise could be shorter"
Hip changes	"blouse the hips slightly"
Leg Cuff changes	"leg cuff"
Pant length changes	"pants were too long"
Thigh changes	"improve room in quad"

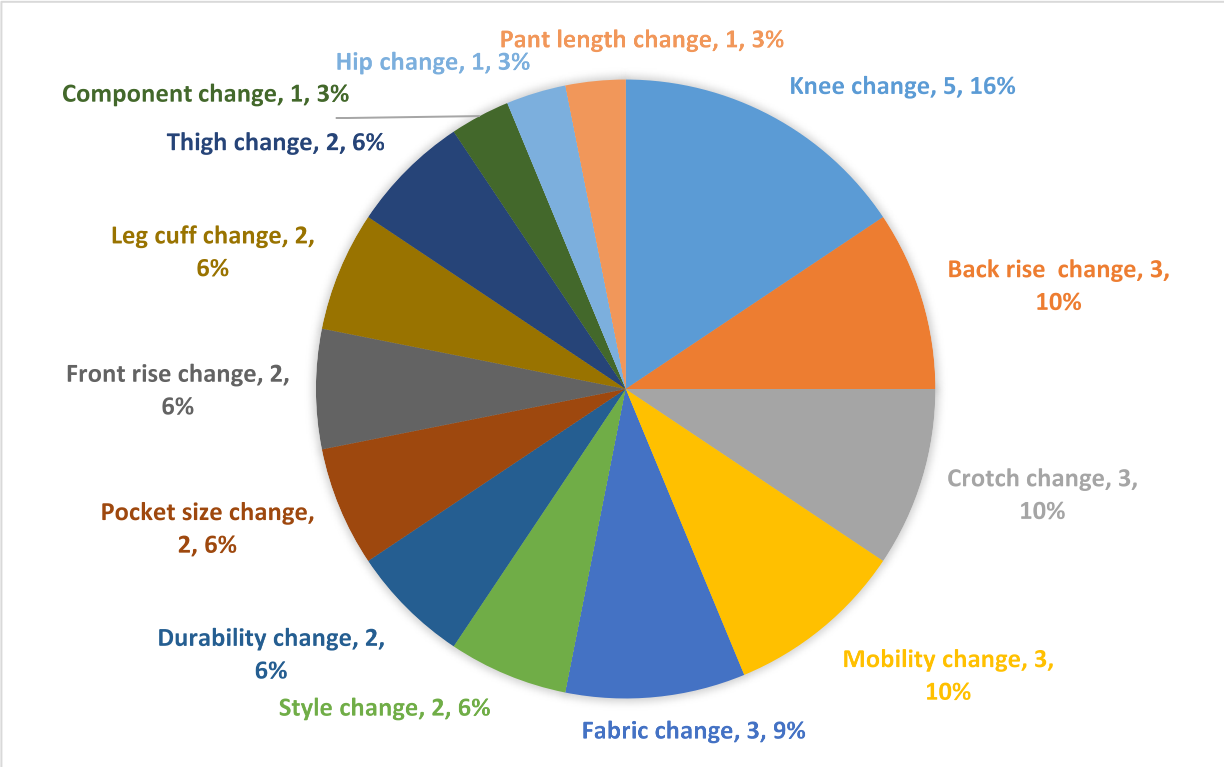


Figure 57. Pie chart showcasing pant comfort change themes with wildland firefighters apparel.

Participants recommended 21 changes to improve shirt comfort, which were placed into 11 themes: (a) back length changes, (b) chest changes, (c) closure changes, (d) collar changes, (e) component changes, (f) equipment interaction changes, (g) fabric changes, (h) shoulder changes, (i) sleeve changes, (j) style changes, and (k) wearable technology changes. Table 36 features the

Table 36

Participant Sample Responses for Shirt Comfort Changes

Theme	Shirt Comfort Responses
Collar changes	"get rid of the Velcro™ collar", "regular collar", and make the collar shorter"
Chest changes	"less extra fabric in back", "more room in back", and "more room in bust"
Style changes	"very baggy", "woman's cut shirt", and "bring back old school shirts"

Table 36 Continued

Theme	Shirt Comfort Responses
Back length changes	“back length” and “longer tail in back”
Shoulder changes	“shoulders” and “shoulder room”
Sleeve changes	“longer sleeves”
Closure changes	“zipper instead of button”
Component changes	“darts in back/waist areas would be ideal”
Equipment Interaction changes	“radio harness bunches shirt”
Fabric changes	“ruff to skin” and “good cotton”
Wearable Technology changes	“A/C cooling packs”

themes and a sample of participant responses for shirt comfort changes. Collars accounted for 19% of the shirt comfort changes, followed by chest and style changes at 14% each. Response totals and percentages for shirt comfort change themes are reported in Figure 58 as a colored pie chart.

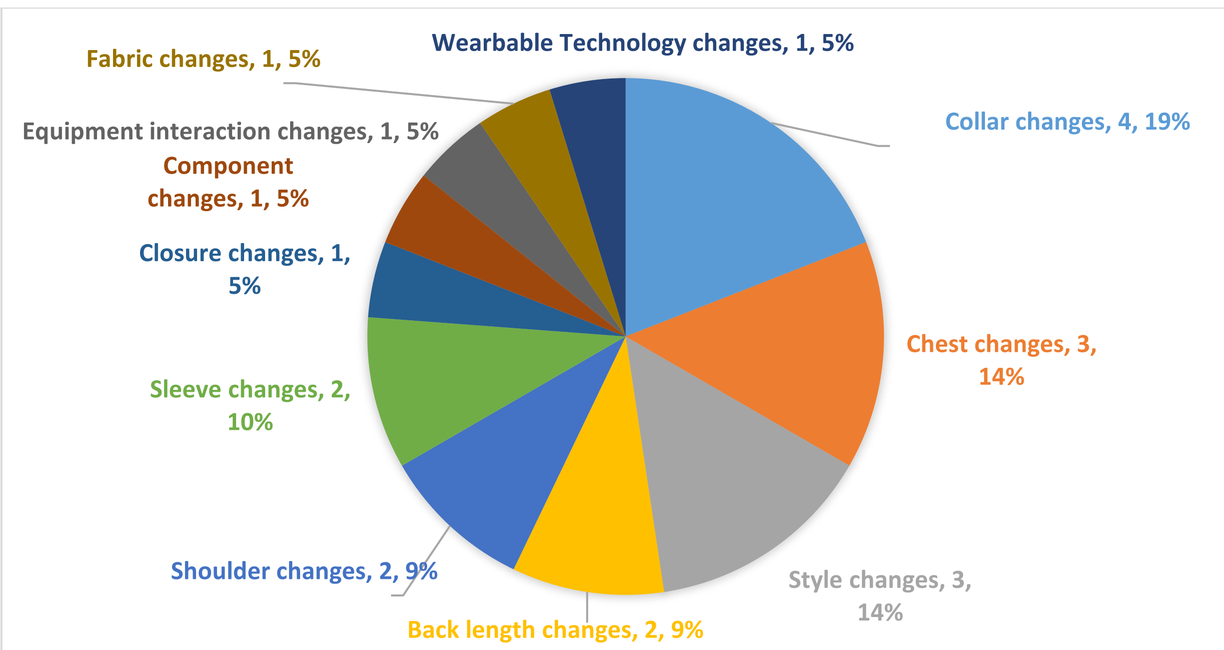


Figure 58. Pie chart showcasing shirt comfort themes with wildland firefighters apparel.

Durability. Descriptive statistics revealed pant durability areas were the most problematic at the crotch (27.4%), followed by knee (14.5%) and Velcro™ (11.3%). Descriptive statistics revealed shirt durability areas were the most problematic with Velcro™ (23.1%), followed by seams (17.9%) and the back (17.9%). Table 37 features the pant and shirt durability areas reported by the wildland firefighters by frequency and percentage.

Table 37

Frequency and Percentages of Durability Problematic Areas of Pants and Shirt

Problematic Areas	Frequency	%
Pant	62	
Crotch	17	27.4%
Knee	9	14.5%
Velcro™	7	11.3%
Ankle	6	9.7%
Pockets	6	9.7%
Buttons or snaps	6	9.7%
Legs	4	6.4%
Front	3	4.8%
Waist	2	3.2%
Zipper	2	3.2%
Shirt	39	
Velcro™	9	23.1%
Back	7	17.9%
Seams	7	17.9%
Button or snaps	6	15.4%
Cuff	3	7.7%
Arms	2	5.1%
Pockets	2	5.1%
Zippers	2	5.1%
Collar	1	2.6%

Performance. Descriptive statistics revealed the participants' perceptions of overall performance of the wildland firefighters pant and shirt were mostly good. Additionally, a one-sample *t*-test was performed to investigate if participants' perceptions of pant and shirt performance were different. A statistically significant difference was found between the pant and shirt for functionality. The pant was perceived as being more functional, $t(52) = 2.310$, $p = .025$, than the shirt. Figure 59 shows the pant and shirt performance means.

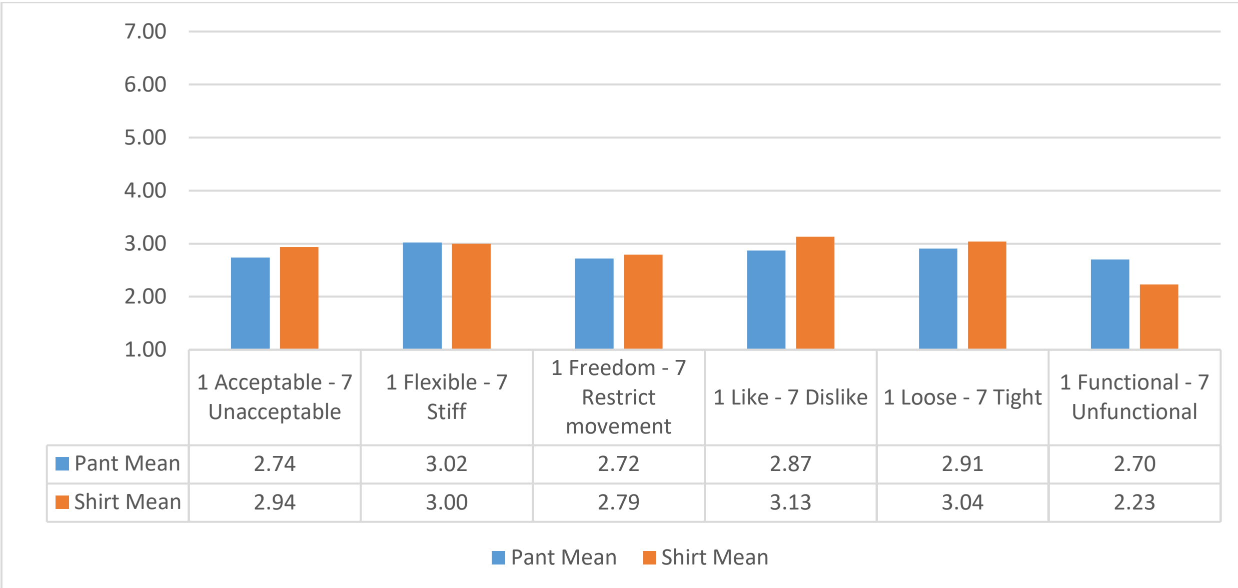


Figure 59. Performance measures for wildland firefighters pant and shirt.

Donning and doffing ease. Descriptive statistics revealed firefighters perceived the ease of donning and doffing the pant and shirt was very good (see Figure 60). Additionally, a one-sample *t*-test was performed to investigate if participants' perceptions of pant and shirt donning and doffing ease were different, and no statistically significant differences were found.

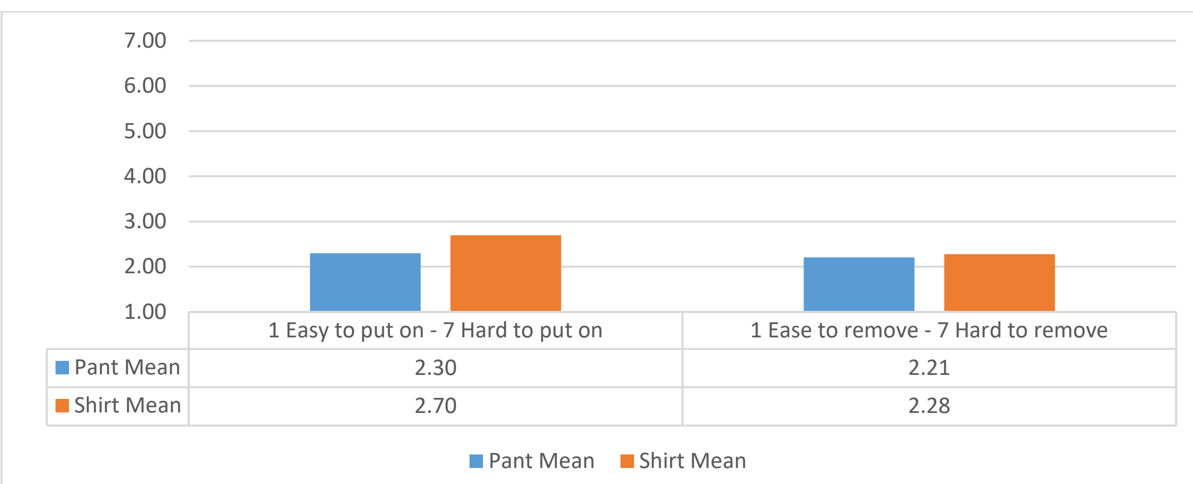


Figure 60. Donning and doffing measures for wildland firefighters pant and shirt.

Components. Apparel components consisted of 21 different design details featured in the wildland firefighters NFPA 1977 apparel. Descriptive statistics revealed that none of the satisfaction level means in the design details were rated above slightly satisfied. Design details rated as slightly satisfied were thigh pocket size, pant slash pocket size, back pocket location, back pocket size, pant slash pock location, thigh pocket location, chest pocket location, chest pocket size, belt loops, gear loops, buckle, and D rings. All other design details (crotch reinforcement panel, arm pocket location, arm pocket size, vents, back pleat, contoured knees, and radio pocket location) were rated as neutral. The means and standard deviations for the design detail satisfaction levels are presented in Table 38.

Table 38

Means and Standard Deviations for Design Detail Satisfaction (n=53)

Design Details	*M*	*SD*
Thigh pocket size	5.53	1.01
Pant slash pocket size	5.45	.93
Back pocket location	5.42	.97
Back pocket size	5.40	.95
Pant slash pock location	5.40	.93
Thigh pocket location	5.38	1.00
Chest pocket location	5.30	.82
Chest pocket size	5.28	.91
Belt loops	5.17	1.09
Gear loops	5.08	.70
Buckle	5.06	.63
D rings	5.04	.68
Crotch reinforcement panel	4.75	1.14
Arm pocket location	4.49	.99
Arm pocket size	4.49	.97
Vents	4.47	.97
Back pleat	4.45	.97
Contoured knees	4.36	.68
Radio pocket location	4.23	.64

Note: Based on 7-point satisfaction (1 = Extremely dissatisfied; 7 = Extremely Satisfied).

Closures. Descriptive statistics were used to report the frequency, mean and standard deviations of satisfaction level for the seven different fasteners and closures in the firefighters' NFPA 1977 apparel. Descriptive statistics revealed that none of the satisfaction level means for fasteners and closures were rated above slightly satisfied. Fasteners and closures rated as slightly satisfied were button and pocket flap closures; all other fasteners and closures (Velcro™, zippers, snaps, zipper pulls, and gusset ankle zipper closure) had a neutral mean. The means and standard deviations for the fasteners and closures satisfaction levels are presented in Table 39.

Table 39

Means and Standard Deviations for Fasteners and Closures Satisfaction (n=53)

Fasteners and Closures	*M*	*SD*
Buttons	5.32	.92
Pocket flap closures	5.11	.82
Velcro™	4.91	1.24
Zippers	4.85	1.13
Snaps	4.57	.89
Zipper pulls	4.55	1.01
Gusset ankle (zipper closure)	4.11	.47

Note: Based on 7-point satisfaction (1 = Extremely dissatisfied; 7 = Extremely Satisfied).

Research Question 4. What are wildland firefighters' perceptions of their NFPA 1977 Protective Clothing based on the production dimension of the Multidimensional Functional Apparel Framework (MFAF): (a) sizing system, (b) quality, (c) ease of care, and (d) availability.

Sizing system. Descriptive statistics revealed that the most reported pant (by waist size) was 34 inches (25.0%), followed by the 36-inch waist pant (21.4%), while the most reported shirt was a size Extra Large (40.0%), followed by the Large (34.0%). Due to the limited number of reported apparel sizes by the participants, no analysis of pant length (*n*=28) could be reported. Table 40 reports the frequency and percentages of the pant and shirt sizing.

Table 40

Frequency and Percentages of NFRP 1977Apparel Sizes

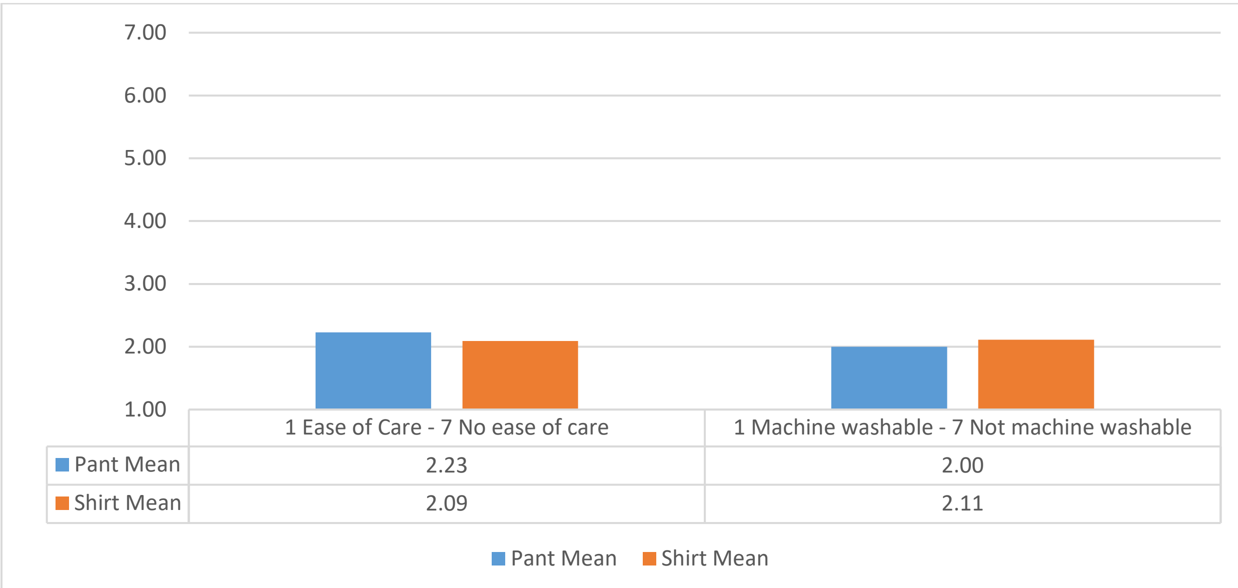
Sizing	Frequency	%
Pant Waist (*n=28)*		
28	3	10.7%
30	4	14.3%
32	2	7.1%
34	**7**	**25.0%**
36	6	21.4%
38	3	10.7%
40	1	3.6%
42	2	7.1%
Shirt (*n=20)*		
X-Small	1	5.0%
Medium	3	15.0%
Large	7	35.0%
X-Large	**8**	**40.0%**
2 X-Large	1	5.0%

Note: No size small shirts were reported.

Quality. Descriptive statistics indicated that participants perceived the quality of the wildland firefighters pant and shirt was good (see Figure 61). Additionally, a one-sample *t*-test was performed to investigate if participants' perceptions of pant and shirt quality were different. There were no statistically significant differences found between the pant and shirt (see Figure 61).

Figure 61. Quality measures for wildland firefighters pant and shirt.

Ease of care. Descriptive statistics revealed that participants perceived the ease of care for the wildland firefighters pant and shirt very good (see Figure 62). Additionally, a one-sample *t*-test was performed to investigate if participants' perceptions of pant and shirt ease of care were different; no statistically significant differences were found.



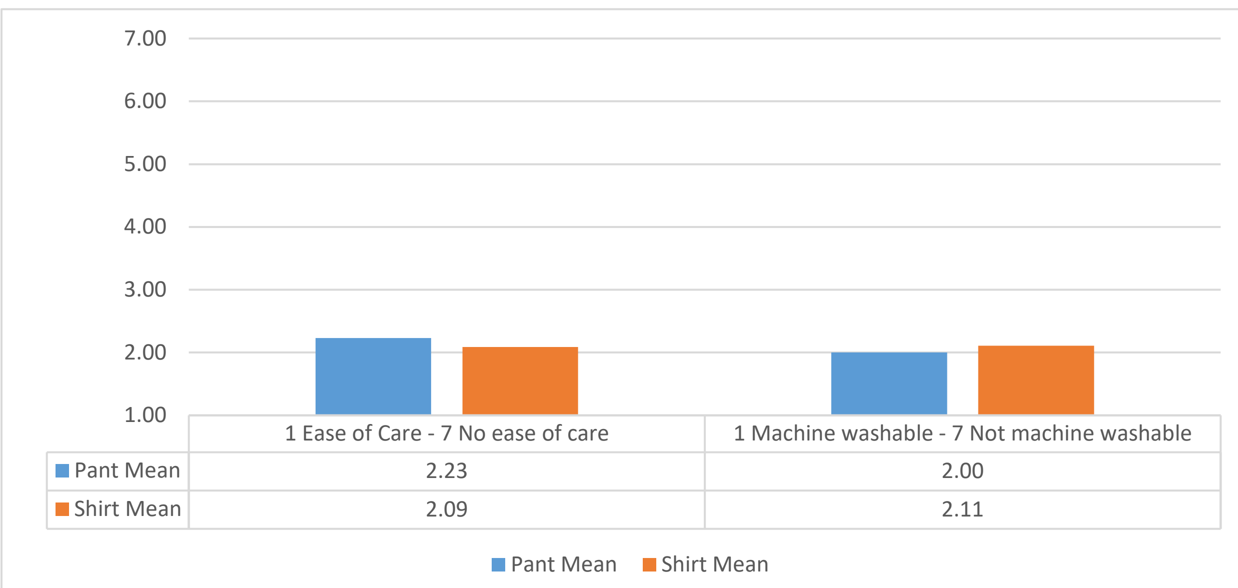


Figure 62. Ease of care measures for wildland firefighters pant and shirt.

Availability. Descriptive statistics revealed availability of wildland firefighters NRFP 1977 apparel had a mean of 4.21 with a standard deviation of 1.39. This indicates participants felt the availability of their apparel was neutral. The majority of the wildland firefighters responded that their NFPA 1977 apparel was provided by their employer (52.8%), followed by purchasing from mail order (30.2%), and online/website (17%). The bar chart, (Figure 63), shows the frequency and type of purchase locations reported by the participants.

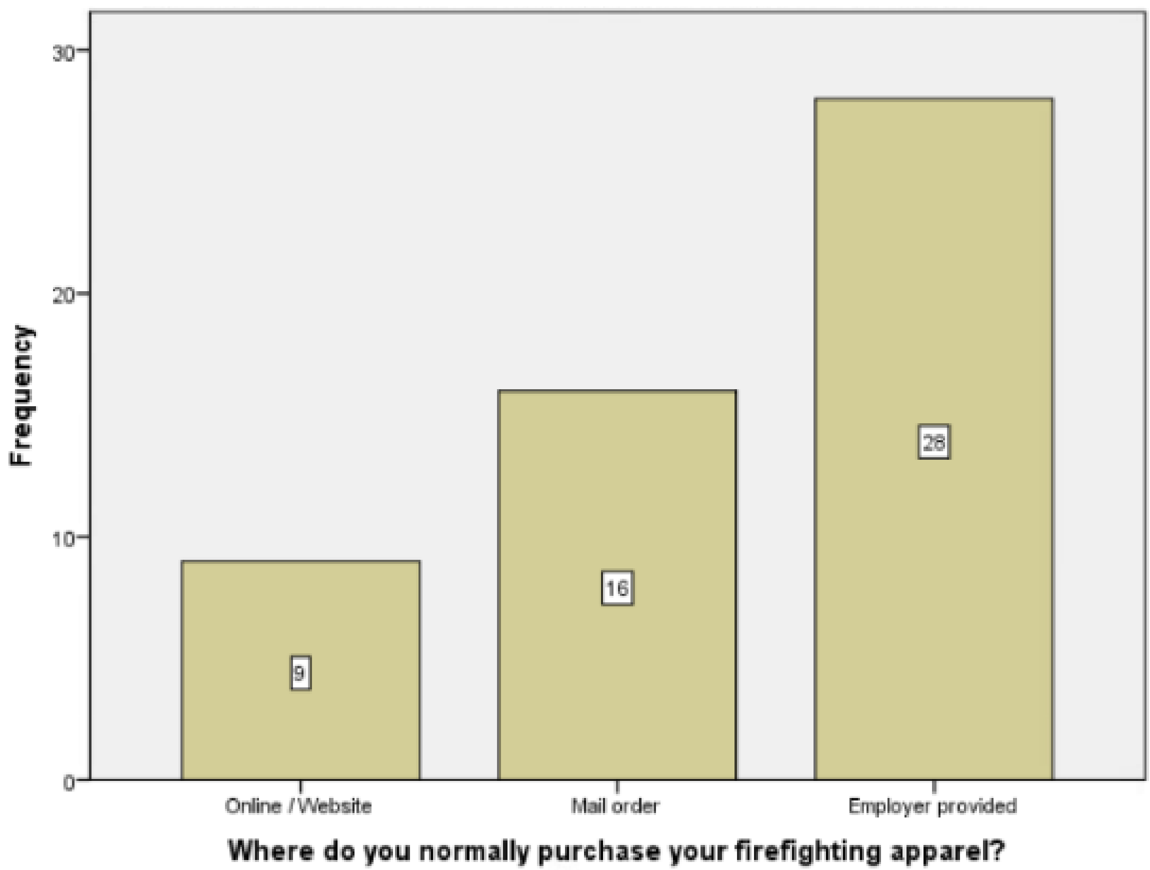


Figure 63. Purchase locations for wildland NRFP 1977 apparel.

Research Question 5. Are there any preferences for a specific NFPA 1977 edition apparel?

Descriptive statistics revealed that wildland firefighters had no preference for a particular NRFP 1977 edition of their pant or shirt. Table 41 features the pant and shirt edition preferences reported by the wildland firefighters by frequency and percentage.

Table 41

Frequency and Percentages of NFPA 1977 Edition Apparel Preferences

NFPR 1977 Editions	Frequency	%
Pants		
2016 Edition	18	21.9%
2005 Edition	13	15.6%
2011 Edition	7	8.5%
Shirt		
2005 Edition	16	19.5%
2011 Edition	11	13.4%
2016 Edition	6	7.3%
No preference	17	20.7%

Additional findings. An open-ended question, "Is there any additional information we should know about how your firefighting apparel could be improved? Explain below." was asked of the participants. Participant comments to this open-ended question revealed 10 themes from 14 responses recommending various changes to: (a) components, (b) closures, (c) durability, (d) affordability, (e) fabric, (f) inseam, (g) pocket size, (h) repair kit, (i) seat, and (j) styles.

Table 42 features the themes and a sample of participant responses for the additional findings.

Table 42

Participant Sample Responses for Additional Findings

Theme	Additional Findings Responses
Component changes	"belt loops could be ¼" longer" "vent options", and "more vents"
Closure changes	"better button" and "zipper option"
Durability issues	"better stitching" and "replacing a button"
Affordability issues	"overpriced"
Fabric changes	"I wish the Nomex material is thinner"
Inseam changes	"short inseam"
Pocket size changes	"slash pockets are too short in newest version of the pants"
Repair kit recommendation	"minor field repairs are sometimes necessary - replacing a button, patching a small hole from a branch stab or ember burn"
Seat changes	"have a women's short with hip/butt room"
Style changes	"hotshot style pant would be cool"

Comments associated with components accounted for 21.4% of the additional finding changes followed by closure changes and durability issues each at 14.3%. Response totals and percentages for additional findings themes are reported in Figure 64 as a colored pie chart.

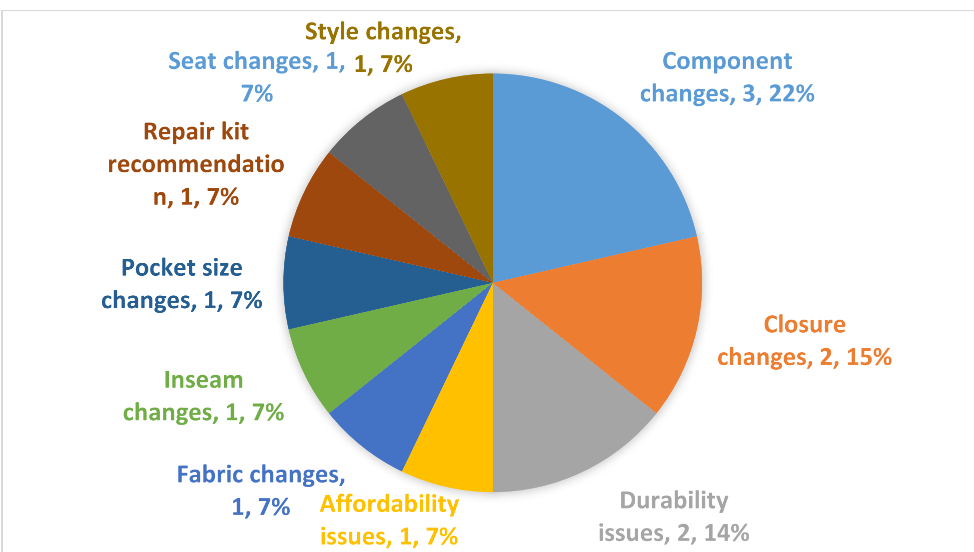


Figure 64. Pie chart showcasing additional findings themes with wildland firefighters apparel.

Multidimensional Functional Apparel Framework

To what extent do the quantitative results agree with the qualitative findings for each of the Multidimensional Functional Apparel Framework (MFAF) variables tested in the separate studies and what additional variables, if any, emerge from the gathering of quantitative data and qualitative open-ended question data in each of the studies? Qualitative and quantitative findings show that product knowledge and perceived need were variables that should be added to the Multidimensional Functional Apparel Framework. The product knowledge variable was revealed in an open-ended question in case study 1. Participants stated they were not aware that sun protective apparel product existed and could be acquired. Product knowledge is a consumer behavior that indicates the end-user is aware that there are apparel options for use and acquisition, along with product alternatives and new product innovations (Sproles, 1979). Case study 2 had a product knowledge question posed as RQ5 "Are there any preferences for a specific difference reported by wildland firefighters in their NFPA 1977 edition 2005, 2011, and 2016 apparel?" The study did not initially categorize as a product knowledge variable in the MFAF.

Perceived need also emerged as a necessary variable for the MFAF based on case study 1. A perceived lack of need was revealed when asking "What perceived deterrents, if any, do parents have for using sun protective clothing on their child?". Some participants stated that they didn't need sun protective apparel because the child wore sunscreen. The majority of the participants in case study 1 were not aware that sun protective apparel provided the best sun protection for their child, but this knowledge could change feelings about sun protective apparel. Product knowledge and perceived need were added to end-user dimension of the MFAF, and a modified Multidimensional Functional Apparel Framework is shown as Figure 65.

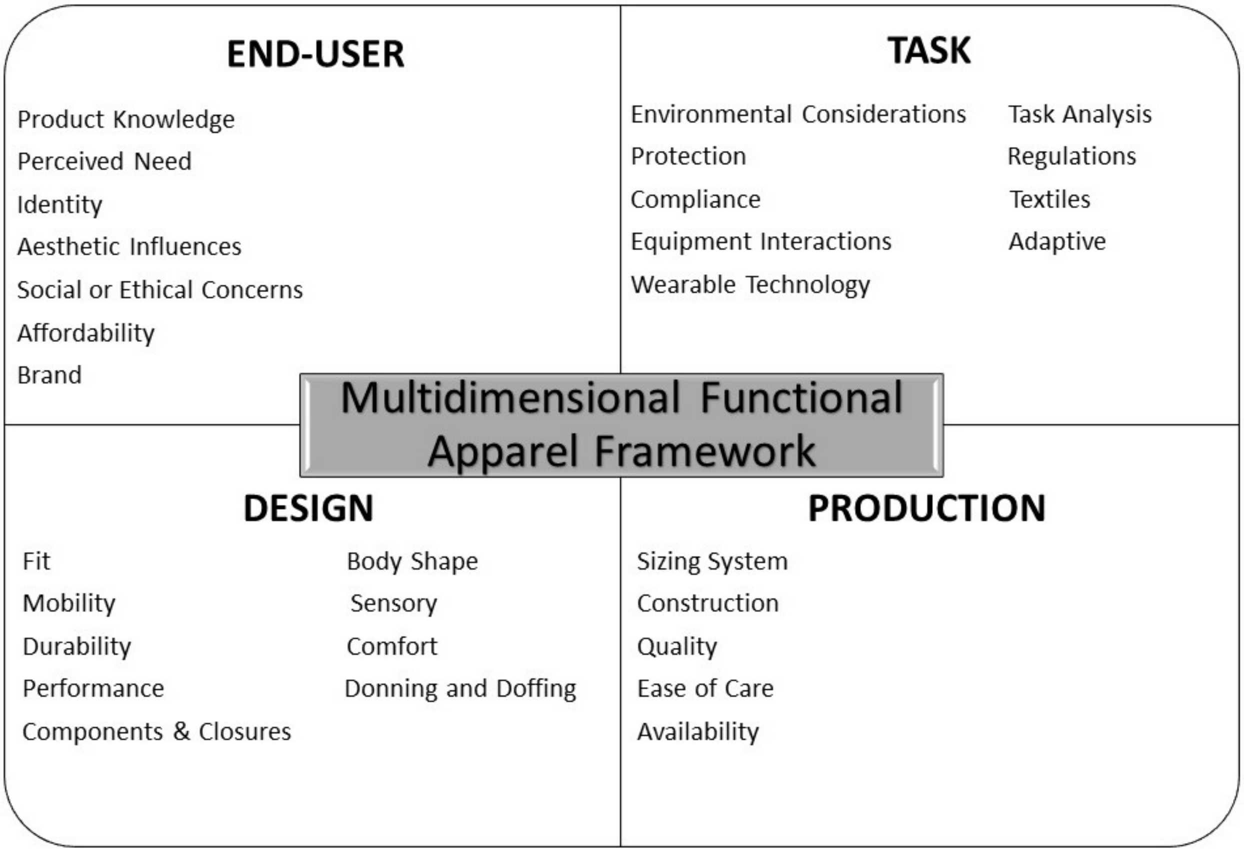


Figure 65. Modified Multidimensional Functional Apparel Framework.

CHAPTER 5. DISCUSSION, IMPLICATIONS, AND LIMITATIONS

This chapter separately discusses the findings of each case study followed by combined implications for the Multidimensional Functional Apparel Framework (MFAF), limitations, as well as suggestions for future research. As previously stated, the purpose of this dissertation was to develop and apply the MFAF using two separate case studies that examined different ages, gender, and types of functional apparel categories using mixed methods.

Case Study 1

Discussion

Case study 1 investigated the usage of and expectations for sun protective apparel in children. A survey was created by the researcher that investigated sun protective characteristics of the user, deterrents to sun protective apparel usage, aesthetic influences, affordability, protection, compliance, textiles, fit, body shape, mobility, durability, comfort, performance, donning and doffing, sizing, construction, quality, ease of care, availability, and participant demographics. The end-user dimension of this study examined deterrents, styles, and affordability. With respect to deterrents to the usage of sun protective apparel, over half of the participants (parents of children) were not aware that sun protective apparel was the best way to protect their child from sun damage while playing in the water and being aware of this knowledge changed their feelings about sun protective apparel. Awareness of an apparel item is a starting point in the consumer decision making process (Sproles, 1979). Without awareness that sun protective apparel exists, a consumer will not know its benefits or know how to locate the apparel for purchase. Bhatt, Silverman, and Dickson (2018) found that new apparel markets could be created or enhanced if consumers are aware of the market and interest can be initiated. Sun protective apparel may still be a new market that needs consumer awareness. This study had participants who had previously owned sun protective apparel but still relied primarily on sunscreen for their child's sun protection while in the water. It could be that participants had purchased sun protective apparel but were unaware that it offered better sun protection than sunscreen. This study found that the majority of participants were not aware that sun protective apparel provided better protection than sunscreen. It has been found that providing information to a consumer about particular apparel has an impact on clothing purchase decisions (Chen-Yu & Seock, 2002). Informing and educating parents through marketing that sun protective apparel is available and is better than sunscreen could improve usage of sun protective apparel for children and bring more awareness to this market. It was through the deterrents question that knowledge of sun protective apparel and the lack of perceived need emerged as the main perceived deterrents to using sun protective apparel.

The styles of sun protective apparel that were used were not answered directly in participants' responses, which mainly referred to the use of sunscreen. The most used sun protective apparel reported was shirts and shorts. Affordability had a low level of agreement so the price of sun protective apparel should be a consideration in the future. Other researchers have found that price can impact the purchase of functional apparel, especially for those with limited incomes or purchasing power (Lee, Jeong, & Kim, 2009; Michaelson, Teel, & Chattaraman, 2018; Na, 2007).

The task dimension of the MFAF found that protection from the sun, compliance, and textiles were mostly satisfying participants' expectations. Participants felt that the child was being protected from the sun, but improvements in compliance and textiles could be seen. Prior researchers saw an increase in sunscreen compliance after parents were educated about the sun's damaging rays and benefits of sunscreen usage (Glanz et al., 2008; Johnson, Davy, Boyett, Weathers, & Roetzheim, 2001; Koch, Pettigrew, Strickland, Slevin, & Minto, 2017). Similar increases in compliance with wearing sun protective apparel could be expected with education and marketing. Textiles may be impacting compliance as researchers have found rough and chafing apparel decreases wearing compliance (Bye & Hakala, 2005; Feather, Ford, & Herr, 1996). While the task dimension for sun protective apparel was meeting expectations, these improvements could increase overall usage of sun protective apparel in children.

The design dimension found participants were somewhat satisfied with fit, body shape, mobility, durability, comfort, and donning and doffing ease. Fit improvements could be made to sun protective apparel, especially in the neckline, waist, seat, and sleeves. Prior research in children's apparel has found improper fit impacts the wearing of children's apparel so proper fit can impact overall compliance (Power, Leaper, & Harris, 2017; Reddy-Best & Harmon, 2015; Shin, Smith, & Gaines, 2015; Zakaria, 2016). Children have different body shapes that change as they grow, therefore this impacts fit and comfort (Chen, Fox, & Haase, 2008; Reddy-Best & Harmon, 2015). Mobility in the water is necessary for swimming, but it can create body exposure or rubbing, especially when jumping or diving into the water (Kwok, Kong, & Fan, 1999). Sports apparel should not impair or cause mobility problems as it can lead to discomfort, pain, and injury (Huck, 1988; Kwok et al., 1999; Stokes & Black, 2012). Researchers have also found that being in the water for an extended time leads to thermal discomfort (Ashdown, 2011; Das & Alagirusamy, 2010; Fan & Tsang, 2008; Kwok et al., 1999; Michaelson, Kim, & Ha, 2018). Wet texiles can rub, irritate the skin causing discomfort, and impair donning and doffing ease, especially with athletic apparel (Boorady, 2006; Bye & Hakala, 2005; Davis & Bishop, 2013; Kwok et al., 1999). Understanding children's sun protective apparel fit, body shapes, mobility, durability, comfort, and donning and doffing ease, and making needed improvements could increase satisfaction for both the child and parents.

The researchers found children's sun protective apparel in the production dimension of the MFAF had somewhat satisfactory expectations with sizing system, construction, quality, ease of care, and availability. Researchers have found that consumers who do not know their sizes or their child's measurements may fall into more than one size, making it difficult to find a proper size (Chun, 2007; Song & Ashdown, 2013; Zakaria, 2016). This can contribute to problems with fit satisfaction and wearing compliance. Poor construction can contribute to improper fit, discomfort, bodily exposure, and poor quality impressions in athletic apparel (Kwok et al., 1999; Perry & Lee, 2017; Wheat & Dickson, 1999). Swimwear is laundered extensively in the summer months to remove chemicals and sunscreen, therefore ease of care is expected along with durability after multiple washings (Fowler, 1999; Kwok et al., 1999). Lastly, availability can be impacted by the lack of awareness and improper sizing system creating an impact on satisfaction levels, especially in athletic apparel (Chae, Black, & Heitmeyer, 2006; Christel & O'Donnell, 2016; Feather et al., 1996; Reddy-Best & Harmon, 2015).

Implications

One of the most important implications from case study 1 was the end-user dimension of the MFAF, especially concerning the lack of knowledge or awareness of sun protective apparel to consumers. Marketing and educational knowledge should be provided to consumers so that sun protective apparel can have a larger market and increase its usage, especially in children. Additionally, such marketing and education can provide knowledge about the greater benefits of sun protective apparel usage compared to sunscreen and the importance of wearing compliance to decrease sunburn and skin cancer. An overall increased consumer awareness can impact not only purchase intentions but may also decrease skin cancer over time if used properly. As children grow at different rates throughout their lives, it is advisable that sun protective apparel is affordable and come in a variety of styles and sizing. While the task, design, and production dimension reported “somewhat” satisfaction levels, there are areas of improvements to be tackled in child sun protective apparel, especially since awareness of this type of apparel is currently lacking in the U.S. market.

Limitations and Future Research

Case study 1 participants largely represented Caucasians; hence the results are not generalizable to the broader U.S. population. The marketing agency used for data collection in case study 1 did provide good national coverage for the sample, but the researchers did not request or obtain any demographics of the sample with respect to income, private or public schools, educational levels, and that limits understanding of how demographic characteristics may have influenced the findings. Future studies should obtain family income and education levels from the participants because affordability and knowledge of sun protective apparel emerged as deterrents to usage. Additionally, the study did not ask if children were wearing sun protective apparel on the day of data collection and only requested parents’ overall perspective on the child’s protective sun apparel. Future studies should address sensory and comfort perceptions of sun protective apparel when wet and dry as this is an area of research that has limited to no body of research. Styles of protective sun apparel needed to be further clarified as not all responses were related to apparel styles, and the researchers were unable to effectively answer their research questions. Future research on styles may also want to identify the preferred shirt sleeve length as that data was not able to be extrapolated from the participant responses in case study 1.

Case Study 2

Discussion

Case study 2 investigated wildland firefighters' perceptions of their NFPA 1977 Protective Clothing along with any perceived functionality differences between NFPA 1977 edition 2005, 2011, and 2016 apparel. Wildland firefighters indicated their pants and shirt fit, mobility, ease of donning and doffing, ease of care, and affordability were very good. Comfort, performance, and quality of the pant and shirt were good. They were only slightly satisfied with the design details and closures on the pants and shirts. Closure improvements were indicated for the Velcro™ closure on the pant and shirt, along with the zippers, zipper pulls, ankle gusset, and snaps. Similar findings with closure problems have been reported with individuals wearing gloves similar to what wildland firefighters are required to wear (Bye & Hakala, 2005; Han, Shin, & Chow, 2015). The availability of NFPA 1977 apparel was rated as neutral; this may be due to most of the wildland firefighters' apparel being employer provided. There was no preference for the edition of NFPA 1977 protective apparel; most participants wore a 2016 edition of the pant and a 2005 edition of the shirt. Both male and female participants saw themselves as having a normal and healthy body shape and most purchased 34-36" waist pants and extra-large shirts. This result indicated wildland firefighters' may be physical fit to complete the required level of physical activity even though participant ages range to over 65 years of age (Faust & Carrier, 2014; McCann & Bryson, 2015; U.S. Forest Service, 2002).

The NFPA 1977 pants were comfortable and performed well but did have equipment interaction problems, as problems have been reported previously by firefighters (Coca, Williams, Roberge, & Powell, 2010; Havenith & Heus, 2004; Huck & Kim, 1997; Park & Hahn, 2014; Park, Park, Lin, & Boorady, 2014). The pant was rated as more lightweight, less irritating, having lower static, and greater functional performance than the shirt. The pant leg cuff was said to need changes for a better fit, greater protection, improved quality of closures, and minimized equipment interaction problems. The crotch needed changes to provide higher satisfaction for mobility, fit, comfort, durability, and more limited equipment interaction problems. The front rise and knees could be improved with fit changes to improve mobility and comfort with additional reinforcement in the knees for overall durability. Participants reported that the back rise had comfort problems and the waist had fit problems. Fit is a common problem with firefighters that has also been reported in other occupations, including police, farmers, pesticide workers, and military personnel (Black & Cloud, 2008; Boorady, Haise, Rucker, & Ashdown, 2009; Choi & Ashdown, 2010; Coca et al., 2010; Huck & Kim, 1997; Park & Hahn, 2014; Park et al., 2014; Parker, Vitalis, Walker, Riley, & Pearce, 2017; Rucker, Anderson, & Kangas, 2000; Rutherford-Black & Khan, 1995). Design detail improvements desired for the pant included crotch reinforcement, contoured knees, vent improvements, and longer belt loops; the latter has been reported by climbers, as well (Lee et al., 2009; Michaelson, Teel, et al., 2018).

The NFPA 1977 shirt was not overall rated as highly as the pant but was still rated as very good. Wildland firefighters' reported fit and mobility problems at the chest and sleeve length. Similar problems with the fit of the chest and sleeve length have been reported in ice hockey, rock climbing, sailing, golf, basketball, and tennis players (Boorady, 2006; Bye & Hakala, 2005; Chae & Evenson, 2014; Feather et al., 1996; Jin & Black, 2012; Michaelson, 2015; Wheat & Dickson, 1999). Participants report collar comfort problems and indicated a need for shirt design detail improvements that included the radio pocket location, back pleat, and the arm pocket size and location. Comfort problems in shirt design have been reported previously by firefighter researchers, especially related to thermal comfort and design details improvements, such as ventilation and cooling systems (Budd et al., 1997; McQuerry, Barker, & DenHartog, 2018; Teunissen et al., 2014). Overall the shirt style could be changed to improve fit and comfort ratings. Based on case study 2 findings, the task and design dimensions were highly important to wildland firefighters and could use the most improvements.

Implications

The tasks performed in the NFPA 1977 shirt and pant along with the design of the shirt and pants require numerous improvements to raise wildland firefighter satisfaction. A visual representation of the NFPA 1977 pant recommended improvements are featured in Figure 66.

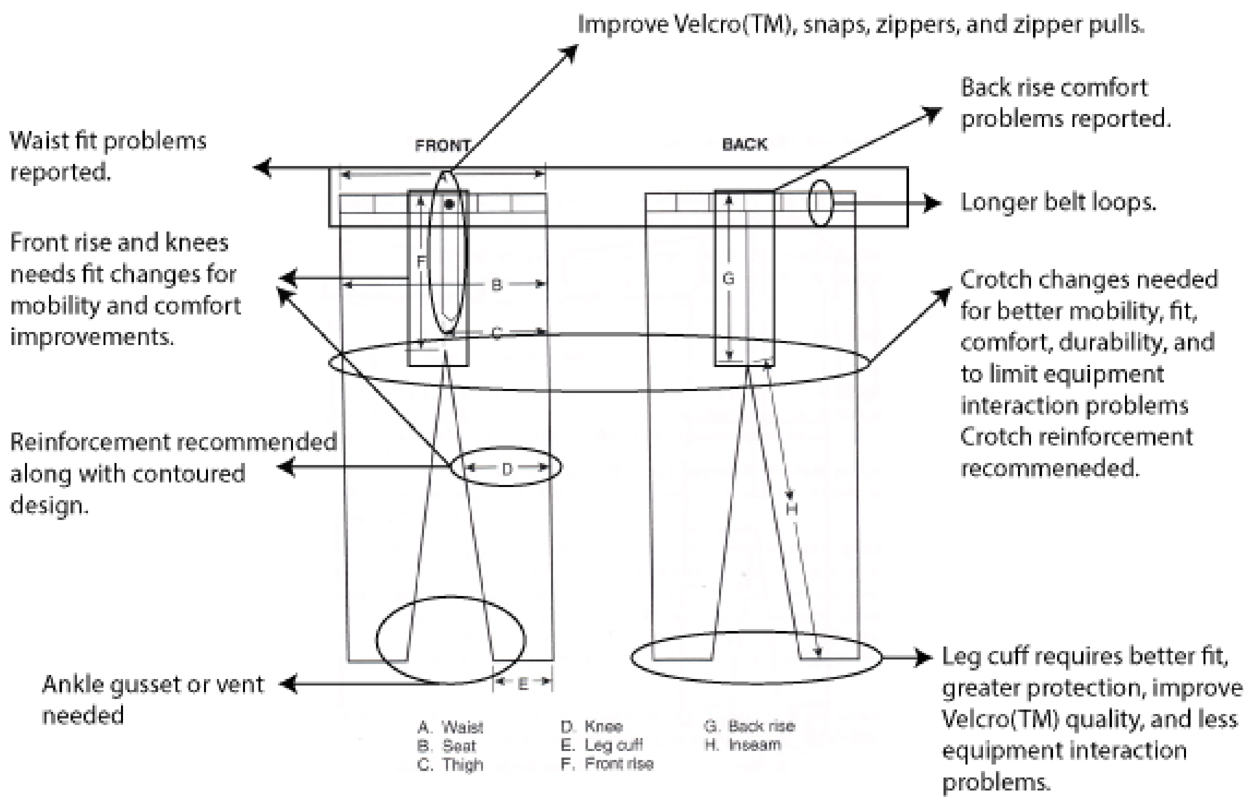


Figure 66. Recommended NFPA 1977 pant improvements.

Pant fit improvements are needed with the waist, front rise, knees, leg cuff and crotch. Many of these changes can be accomplished by evaluating current NFPA 1977 sizing regulations and recommendations for changes in sizing and ease requirements. Comfort problems with the front and back rise, knees, and crotch could be alleviated through fit improvements. Design details that can aid comfort are reinforcements to the knees and ventilation at the ankle. Equipment interactions are impacting the crotch and leg cuff areas of the pant and should be investigated further to identify a solution. Closure quality of the Velcro™, snaps, zippers, and zipper pull needs to be improved. A recommendation to change NFPA 1977 closure testing and requirements for these closures should be instigated.

Figure 67 features the recommended improvements on the technical sketch of a NFPA 1977 shirt. Overall, the shirt style can be improved for better fit and comfort by correcting chest and sleeve lengths, improving the back pleat, collar, and closures, and changing the arm pocket location and size along with changing the radio pocket location. Many of these areas also impact the mobility of the wildland firefighter, which can impede performance and safety. Designers

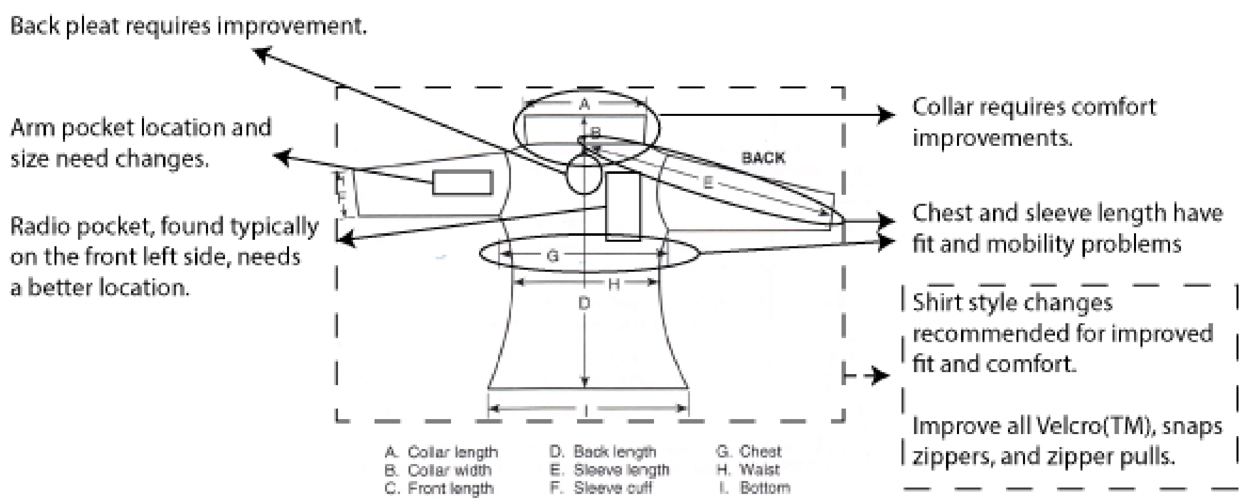


Figure 67. Recommended NFPA 1977 shirt improvements.

and manufacturers of NFPA 1977 apparel should take note of these problematic areas and seek to make the necessary improvements to both garments. These shirt improvements can aid in the comfort and protection of wildland firefighters.

Due to the lower number of participant responses, the findings of this study may not be a representation of all wildland firefighters in the United States. An additional study is recommended to obtain more wildland firefighters' responses before a generalization of all findings can be made for the entire U.S. population. Future researchers may wish to focus on gender specific NRPA 1977 apparel as there were only four female respondents, but they reported improvements and changes were necessary. Male wildland firefighters may require different NRPA 1977 apparel improvements than their female counterparts. Closure improvements need to be addressed with additional research and reporting to the NRPA for a possible regulation or testing change. Manufacturers of wildland firefighter apparel may wish to address style, fit, mobility, comfort, protection, durability, components, and design details in the future changes posed by the next NRPA 1977 edition change pending in 2020.

Limitations and Future Research

Case study 2 had limited sample size, which limits the generalizability of the findings. There were only four female participants, so the researchers were unable to make any meaningful recommendations based on this limited response. Additional data would need to be collected in the future for case study 2 to make any of the findings generalizable and develop recommendations for female fire fighters. Future research investigating the location and size of pockets is needed to mitigate equipment interaction problems and provide higher satisfaction ratings. Study findings reported closure types needed improvement, but the nature of the exact problem that the wildland firefighters were experiencing is unknown beyond that the fact the closures do not meet their quality satisfaction standards. Interview studies are recommended for future research to investigate specific fit, comfort, protection, and mobility issues faced by fire fighters in further detail, and these interviews should include field testing with typical equipment.

Implications for Multidimensional Functional Apparel Framework

Case study 1 and 2 findings confirm that the modified MFAF can be used to investigate a variety of functional apparel categories and demographics along with identifying new variables if using a mixed methods approach. Each dimension of the MFAF has a different impact based on the type of usage. Case study 1, recreational apparel for children, revealed that the end-user dimension was the most impactful. Case study 2 findings suggested that the task and design dimension were the most beneficial for wildland firefighters. Based on the apparel usage – everyday, medical, sports, or occupational – each dimension may have a different hierarchy of importance for the end-user when evaluating functional apparel. Open-ended questions, or other qualitative research designs used in mixed methods, should be employed to gain more insight into each of the dimension variables in future research. These two case studies found the use of mixed methods both enhanced existing variables and aided in identifying new variables. Continued use of mixed method research, while applying the MFAF, can validate each dimension while determining if specific types of apparel usage – everyday, medical, sport, and occupation – have specific dimension hierarchy. Given these two studies results, it would appear that the end-user dimension is more important for everyday functional apparel while occupational apparel relies on task and design dimensions for importance.

The study findings indicate that everyday functional apparel may rely more heavily on the end-user dimension due to the individuals wearing the apparel in a social setting or structure. Proper acceptance in a social setting relies on appropriate and aesthetically pleasing apparel even if the apparel is functional (Burke & Reitzes, 1991; Stets & Serpe, 2016). Additionally, everyday apparel is purchased regularly, so social and ethical concerns, affordability, and brand can have high importance (Ahsan & Tullio-Pow, 2015; Chan, Esteve, Fourniols, Escriba, & Campo, 2012; Dodds, Monroe, & Grewal, 1991; Ironico, 2012; Na, 2007). Future research into everyday functional apparel can validate if the end-user dimension is the most important dimension of the MFAF.

Study 2 results indicate occupational apparel relies on task and design dimensions more highly than other MFAF dimensions and is supported by prior research where the task, environment, equipment, textile, fit, mobility, comfort, protection, and performance have been reported as being important and needing improvement (Adams & Keyserling, 1996; Barker & Black, 2009; Boorady et al., 2009; Brandt & Cory, 1989; Chan et al., 2015; Coca et al., 2010; Ilmarinen, E., & Korhonen, 1990; Naesgaard, Storholmen, Wiggen, & Reitan, 2017; Park & Hahn, 2014; Perkins, Crown, Rigakis, & Eggertson, 1992; Tremblay-Lutter, Crown, & Rigakis, 1996). Occupational workers rely on their functional apparel to protect them while they are working (Boorady, 2011; Watkins & Dunne, 2015). Gupta (2011) reported that occupational apparel needed to provide the necessary protection in extreme environments, against cuts, impacts, and hazardous conditions, and even to monitor the physiological condition of the end-user. Various research studies have also shown the importance of textiles in occupational work to protect the end-user (Buckley, 2005; Dammacco, Turco, & Glogar, 2012; Fenne, 2005; Gon & Paul, 2011; Hearle, 2005; Laing & Sleivert, 2002; Makinen, 2005). New advances in wearable technology and adaptive clothing will continue to improve occupational apparel, especially with disabled workers or those working in extreme environments (Chan et al., 2012; McCann & Bryson, 2009; Parker et al., 2017; Rantanen et al., 2000; Watkins & Dunne, 2015).

The modified Multidimensional Functional Apparel Framework (see Figure 65), should be applied to future functional apparel research as a means of further testing the framework. The use of the modified MFAF can improve the way researchers, designers, and manufacturers produce functional apparel by providing a comprehensive look at relevant variables. Even though prior literature on functional apparel may not have investigated these variables, utilizing the MFAF with a mixed method approach can aid the researcher in identifying additional areas of improvements or change that are needed in the functional apparel. The lack of an inclusive Multidimensional Functional Apparel Framework has led to inconsistencies, such as not investigating all variables, in prior research studies, so the use of the modified MFAF can provide more meaningful and consistent findings with future research. Findings from the modified MFAF can aid in the development and change of regulations for various functional apparel types to improve the end-user's overall well-being and safety. Innovations in functional apparel, such as wearable technology, can be investigated by implementing the modified MFAF to better understand end-user's needs and behaviors for new functional apparel. Because the MFAF was applied to just two separate case studies, it should be noted that future research studies using the modified MFAF may find additional variables to update. This is due to the limited number of completed functional apparel studies and the multitude of functional apparel needs that are constantly changing and evolving.

Overall, the modified MFAF will need to be validated further in future functional apparel research studies. The use of mixed method research with the modified MFAF is recommended, especially if the researchers are looking at a new or innovative type of functional apparel or functional apparel with limited or no prior research foundation. Future research utilizing the modified MFAF will allow for the framework to be tested on a variety of functional apparel types and end-users' needs, thereby showcasing the modified MFAF's flexibility in different research function apparel studies. The modified MFAF can be utilized outside the field of apparel design studies and be applied to medical, sports, or even ergonomic research fields where apparel is used for specific functions.

Recommendations for Future Usage of MFAF

Future functional apparel research using the MFAF should start with solid research design. This researcher advocates the use of mixed methods research design so more in-depth and generalizable findings can be obtained in future functional apparel research. While this study used convergent mixed methods in both case studies, other mixed methods research, including explanatory sequential or exploratory sequential design, can be used to get the results based on the functional apparel research problem being investigated (Creswell & Plano Clark, 2018). The variables in each MFAF dimension should be used to aid in the literature review of the apparel problem being investigated. By investigating each variable, a more intensive review of the functional apparel literature can be achieved so the proper hypotheses or research questions can be identified that are central to the problem. While not all variables may be used in the research study, the design of the study will be stronger as more variables would have been investigated prior to starting the study. As with case study 1, sensory problems were not investigated in the study, yet the mixed methods design aided in showing that sensory problems were an issue for children using sun protective apparel. By using the MFAF during the literature review, other apparel studies that had experienced sensory problems were known by the researcher and aided in the results and discussion of the study, and this strengthens the future of functional apparel studies. Future researchers may find that particular dimensions of the MFAF are represented in literature for specific apparel problems, yet other problems may exist, and by using the MFAF all variables can be understood prior to the start of their study. Ultimately, as functional apparel researchers we wish to design and research important problems to aid consumers, designers, and manufacturers with their functional apparel, so using the MFAF can aid in building the strongest apparel research design for the future of functional apparel.

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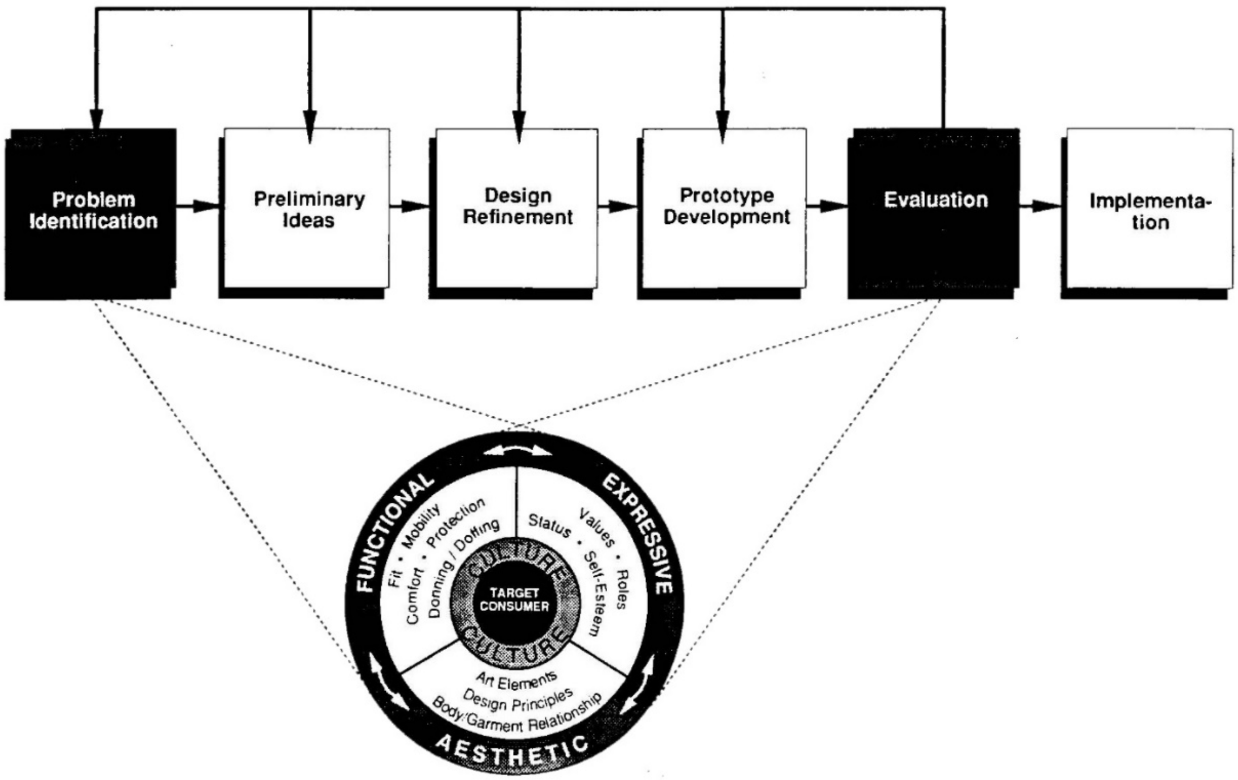
APPENDIX A.1 – Lamb & Kallal's (1992) Functional, Expressive, and Aesthetic Consumer Needs Model



APPENDIX A.2 – DeJonge's functional clothing design process and strategy selection model, featured in the forward of *Clothing: The portable environment* by Watkins (1984)

FUNCTIONAL CLOTHING DESIGN PROCESS AND STRATEGY SELECTION

	2 Design situation explored	3 Problem structure perceived	4 Specifications described	5 Design criteria established	6 Prototype developed	7 Design evaluation
1 Request made	1.2 State general objective; Brainstorming; User interview and observation; Visual inconsistency; Literature search					
2 Design situation explored		2.3 Brainstorming; Observation analysis; Market analysis; Literature search; Identification of critical factors; Definition of problem				
3 Problem structure perceived	3.2 Brainstorming; Visual inconsistency; Reassess critical factors		3.4 Activity assessment; Movement assessment; Impact assessment; Thermal assessment; Social-psychological assessment			
4 Specifications described	4.2 State objectives; Check specifications against objectives	4.3 Reassess critical factors		4.5 Charting; Ranking and weighing; Prioritizing		
5 Design criteria established	5.2 State objectives; Check criteria against objective	5.3 Identify critical factors	5.4 Literature review of assessment areas to check specifications		5.6 Materials testing; Technique evaluation; Brainstorming; Creative integration; Solutions weighed against criteria	
6 Prototype developed	6.2 Visual inconsistency; Identify objective; User interview	6.3 Identify critical factors	6.4 Literature review of assessment areas	6.5 Rank order specifications		6.7 Specification testing; User satisfaction

APPENDIX A.3 – Seven principles of Universal Design (Connell et al., 1997)

THE PRINCIPLES OF UNIVERSAL DESIGN

Version 2.0 4/1/97

1 EQUITABLE USE

The design is useful and marketable to people with diverse abilities.

GUIDELINES
- 1a. Provide the same means of use for all users: identical whenever possible; equivalent when not.
- 1b. Avoid segregating or stigmatizing any users.
- 1c. Make provisions for privacy, security, and safety equally available to all users.
- 1d. Make the design appealing to all users.

EXAMPLES
- Power doors with sensors at entrances that are convenient for all users
- Integrated, dispersed, and adaptable seating in assembly areas such as sports arenas and theaters

2 FLEXIBILITY IN USE

The design accommodates a wide range of individual preferences and abilities.

GUIDELINES
- 2a. Provide choice in methods of use.
- 2b. Accommodate right- or left-handed access and use.
- 2c. Facilitate the user's accuracy and precision.
- 2d. Provide adaptability to the user's pace.

EXAMPLES
- Scissors designed for right- or left-handed users
- An automated teller machine (ATM) that has visual, tactile, and audible feedback, a tapered card opening, and a palm rest

3 SIMPLE AND INTUITIVE USE

Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.

GUIDELINES
- 3a. Eliminate unnecessary complexity.
- 3b. Be consistent with user expectations and intuition.
- 3c. Accommodate a wide range of literacy and language skills.
- 3d. Arrange information consistent with its importance.
- 3e. Provide effective prompting and feedback during and after task completion.

EXAMPLES
- A moving sidewalk or escalator in a public space
- An instruction manual with drawings and no text

4 PERCEPTIBLE INFORMATION

The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.

GUIDELINES
- 4a. Use different modes (pictorial, verbal, tactile) for redundant presentation of essential information.
- 4b. Maximize "legibility" of essential information.
- 4c. Differentiate elements in ways that can be described (i.e., make it easy to give instructions or directions).
- 4d. Provide compatibility with a variety of techniques or devices used by people with sensory limitations.

EXAMPLES
- Tactile, visual, and audible cues and instructions on a thermostat
- Redundant cueing (e.g., voice communications and signage) in airports, train stations, and subway cars

5 TOLERANCE FOR ERROR

The design minimizes hazards and the adverse consequences of accidental or unintended actions.

GUIDELINES
- 5a. Arrange elements to minimize hazards and errors: most used elements, most accessible; hazardous elements eliminated, isolated, or shielded.
- 5b. Provide warnings of hazards and errors.
- 5c. Provide fail safe features.
- 5d. Discourage unconscious action in tasks that require vigilance.

EXAMPLES
- A double-cut car key easily inserted into a recessed keyhole in either of two ways
- An "undo" feature in computer software that allows the user to correct mistakes without penalty

6 LOW PHYSICAL EFFORT

The design can be used efficiently and comfortably and with a minimum of fatigue.

GUIDELINES
- 6a. Allow user to maintain a neutral body position.
- 6b. Use reasonable operating forces.
- 6c. Minimize repetitive actions.
- 6d. Minimize sustained physical effort.

EXAMPLES
- Lever or loop handles on doors and faucets
- Touch lamps operated without a switch

7 SIZE AND SPACE FOR APPROACH AND USE

Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility.

GUIDELINES
- 7a. Provide a clear line of sight to important elements for any seated or standing user.
- 7b. Make reach to all components comfortable for any seated or standing user.
- 7c. Accommodate variations in hand and grip size.
- 7d. Provide adequate space for the use of assistive devices or personal assistance.

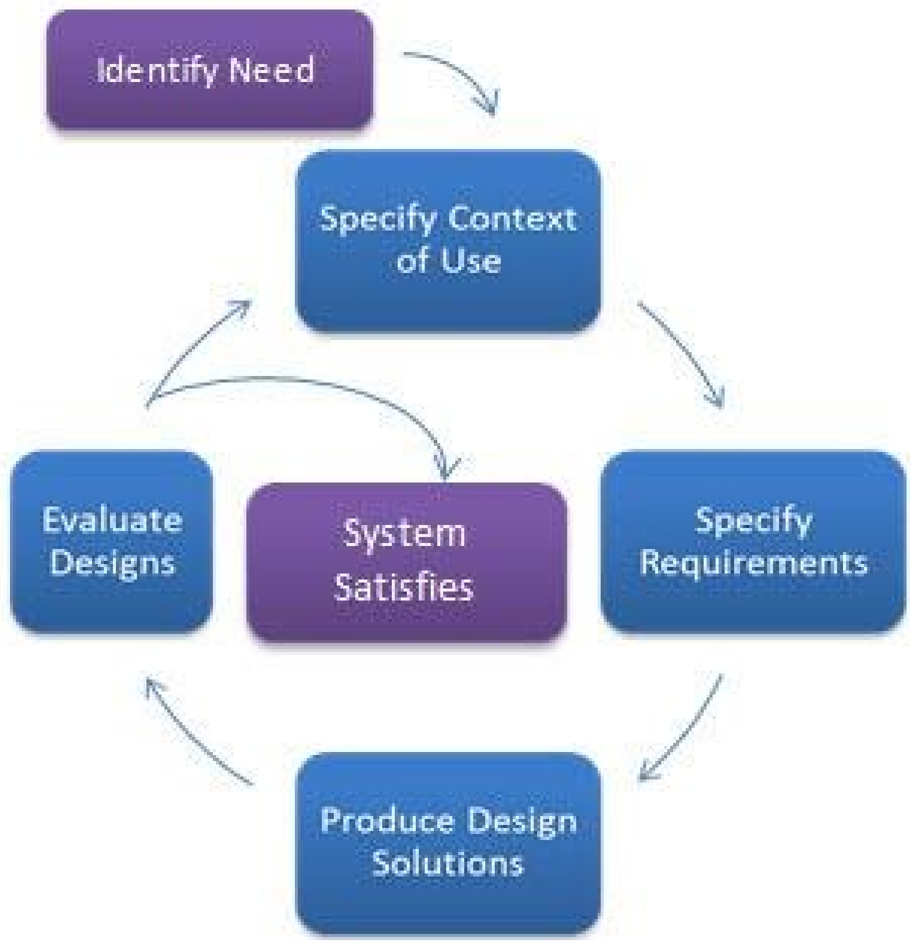
EXAMPLES
- Controls on the front and clear floor space around appliances, mailboxes, dumpsters, and other elements
- Wide gates at subway stations that accommodate all users

THE PRINCIPLES WERE COMPILED BY ADVOCATES OF UNIVERSAL DESIGN, IN ALPHABETICAL ORDER:

Bettye Rose Connell, Mike Jones, Ron Mace, Jim Mueller, Abir Mullick, Elaine Ostroff, Jon Sanford, Ed Steinfeld, Molly Story, and Gregg Vanderheiden.

NOTE:
The Principles of Universal Design are not intended to constitute all criteria for good design, only universally usable design. Certainly, other factors are important, such as aesthetics, cost, safety, gender and cultural appropriateness, and these aspects must also be taken into consideration when designing.

APPENDIX A.4 - Phases of User-Centered Design (U.S. Department of Health & Human Sciences, n.a.)



APPENDIX B.1 – Functional Apparel Literature Review: End-User Dimension

				End-User Dimension				
Source	**End User Apparel Type**	**Framework Used**	**Name of Framework**	**Identity**	**Aesthetic Influences**	**Social or Ethical Concerns**	**Affordability**	**Brand**
Ahsan, N., & Tullio-Pow, S. (2015). Functional clothing for natural disaster survivors. *Disaster Prevention and Management: An International Journal, 24* (3), 306-319.	Everyday	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X	X	X	X	
An, S. K., & Domina, T. (2015). Thermal comfort difference on gender under military garment system using thermal manikin. *AATCC Journal of Research, 2* (3), 1-5.	Occupational							
Anand, N. (2011). Pattern engineering and functional clothing. *Indian Journal of Fibre & Textile Research, 36* (4), 358-365.	Review				X			
Baig, M. M., Gholamhosseini, H., & Connolly, M. J. (2013). A comprehensive survey of wearable and wireless ECG monitoring systems for older adults. *Medical & Biological Engineering & Computing, 51* (5), 485-495.	Everyday			X		X	X	
Barker, J., & Black, C. (2009). Ballistic vests for police officers: Using clothing comfort theory to analyse personal protective clothing. *International Journal of Fashion Design, Technology and Education, 2* (2-3), 59-69.	Occupational	X	Branson and Sweeney's Clothing Comfort Model (1991)	X	X			X
Bechtold, T., Caven, B., & Wright, T. (2015). Sportswear for snow sports. In R. Shishoo (Ed.), *Textiles for Sportswear* (pp. 245-265). Cambridge, UK: Woodhead Publishing Limited.	Sport				X			
Belkin, N. (1993). The challenge of defining the effectiveness of protective aseptic barrier, *Technical Textiles International, 2* (5), 22-24.	Occupational							
Bergen, M. E., Capjack, L., McConnan, L. G., & Richards, E. (1996). Design and evaluation of clothing for the neonate. *Clothing and Textiles Research Journal, 14* (4), 225-233.	Medical	X	DeJonge's (1984) Design process model in *Clothing: The portable environment* by Watkins (1984)		X		X	
Biswas, T. T., Infirri, R. S., Hagman, S. & Berglin, L. (2018). An assistive sleeping bag for children with autism spectrum disorder. *Fashion and Textiles, 5* (18), 1-12.	Everyday							
Black, C., & Cloud, R. M. (2008). Assessing functional clothing needs of bicycle patrol officers. *International Journal of Fashion Design, Technology and Education, 1* (1), 35-42.	Occupational	X	DeJonge's (1984) Design process model in *Clothing: The portable environment* by Watkins (1984)	X	X			X
Black, C., Freeman, C., & Rawlings, A. (2018) Problem-based learning: Design development of female chef's jackets, *International Journal of Fashion Design, Technology and Education, 11* (1), 123-128.	Occupational	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X	X			
Black, S., Kapsali, V., Bougourd, J., & Geesin, F. (2005). Fashion and funtion - factors affecting the design and use of protective clothing. In R. A. Scott (Ed.), *Textiles for protection* (pp. 60-89). Boca Raton, FL: Woodhead Publishing Limited.	Occupational	X		X	X		X	
Block, C. B. (1976). Functional clothing design. *Occupational Health*, *February*, 79-85.	Occupational							
Boorady, L. M. (2006). Impact protection equipment for female ice hockey players. *Research Journal of Textiles and Apparel, 10* (4), 67-72.	Sport			X	X			
Boorady, L. M. (2011). Functional clothing - Principles of fit. *Indian Journal of Fibre & Textile Research, 36* (4), 344-347.	Review				X			
Boorady, L. M., Haise, C., Rucker, M., & Ashdown, S. P. (2009). Protective clothing for pesticide applicators: A multimethod needs assessment. *Journal of Textile and Apparel, Technology and Management, 6* (2), 1-17.	Occupational			X	X		X	X

APPENDIX B.1 – Functional Apparel Literature Review: End-User Dimension

				End-User Dimension				
Source	**End User Apparel Type**	**Framework Used**	**Name of Framework**	**Identity**	**Aesthetic Influences**	**Social or Ethical Concerns**	**Affordability**	**Brand**
Braganca, S., Castellucci, I., Gill, S., Matthias, P., Carvalho, M., & Arezes, P. (2018). Insights on the apparel needs and limitations for athletes with disabilities: The design of wheelchair rugby sports-wear. *Applied Ergonmics, 67* , 9-25.	Sport				X		X	X
Brandt, B., & Cory, E. M. (1989). Garments worn by production workers in cleanrooms: A needs assessment. *Clothing and Textiles Research Journal, 7* (4), 27-34.	Occupational						X	
Burns, W. (2015). Experiences in the design, iterative development and evaluation of a technology-enabled garment for active ageing walkers. In J. McCann and D. Bryson (Eds.), *Textile-led design for the active ageing population* (pp. 509-533). Cambridge, UK:Woodbridge Publishing Limited.	Sport			X			X	
Bye, E., & Hakala, L. (2005). Sailing apparel for women: A design development case study. *Clothing and Textiles Research Journal, 23* (1), 45-55.	Sport	X	Watkins (1995) & Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X	X		X	X
Carroll, K. E., & Kincade, D. H. (2007). Inclusive design in apparel product development for working women with physical disabilities. *Family and Consumer Sciences Research Journal, 35* (4), 289-315.	Everyday	X	Inclusive design by Center for Universal Design at North Carolina State University (1997)	X	X			
Casselman-Dickson, M. A., & Damhorst, M. L. (1993). Female bicyclists and interest in dress: Validation with multiple *measures. Clothing and Textiles Research Journal, 11* (4), 7-17.	Sport	X	Solomon's Symbolic Use of Products (1983)	X	X			
Chae, M. (2017). An innovative teaching approach to product development: Creating tennis wear for female baby boomers. Fashion and Textiles, 4(13), 1-17.	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X	X			
Chae, M., & Evenson, S. (2014). Prototype development of golf wear for mature women. *International Journal of Fashion Design, Technology and Education, 7* (1), 2-9.	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X	X			
Chae, M., & Schofield-Tomschin, S. (2010). Investigation of design characteristics and regulatory requirements for snowboarding helmets. *International Journal of Fashion Design, Technology and Education, 3* (2), 89-97.	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X	X		X	
Chae, M.-H., Black, C., & Heitmeyer, J. (2006). Pre-purchase and post-purchase satisfaction and fashion involvement of female tennis wear consumers. *International Journal of Consumer Studies, 30* (1), 25-33.	Sport				X		X	X
Chan, A. P., Guo, Y. P., Wong, F. K., Li, Y., Sun, S., & Han, X. (2015). The development of anti-heat stress clothing for construction workers in hot and humid weather. *Ergonomics* , 1-17.	Occupational	X	DeJonge's (1984) Design process model in *Clothing: The portable environment* by Watkins (1984)		X			
Chang, H. J., Hidges, N., & Yurchisin, J. (2014). Consumers with disabilities: A qualitative exploration of clothing selelction and use among female college students. *Clothing and Textiles Research Journal, 32* (1), 34-48.	Everyday	X	Self-efficacy Theory (Bandura, 1977)	X	X	X		
Chang, W.-M., Zhao, Y.-X., Guo, R.-P., Wang, Q., & Gu, X.-D. (2009). Design and study of clothing structure for people with limb disabilities. *Journal of Fiber Bioengineering and Informatics, 2* (1), 62-67.	Review			X	X		X	
Chen, X., & Chaudhry, I. (2005). Ballistic protection. In R. A. Scott (Ed.), *Textiles for Protection* (pp. 529-556). Cambridge, UK: Woodhead Publishing Limited.	Occupational				X			

APPENDIX B.1 – Functional Apparel Literature Review: End-User Dimension

				End-User Dimension				
Source	**End User Apparel Type**	**Framework Used**	**Name of Framework**	**Identity**	**Aesthetic Influences**	**Social or Ethical Concerns**	**Affordability**	**Brand**
Cho, H. S., Koo, S. M., Lee, J., Cho, H., Kang, D. H., Song, H. Y., . . . Lee, Y. J. (2011). Heart monitoring garments using textile electrodes for healthcare applications. *Journal of Medical Systems, 35* (2), 189-201.	Medical							
Cho, K. (2006). Redesigning hospital gowns to enhance end users' satisfaction. *Family and Consumer Sciences Research Journal, 34* (4), 332-349.	Medical	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X	X		X	
Choi, M.-S., & Ashdown, S. P. (2002). The design and testing of work clothing for female pear farmers. *Clothing and Textiles Research Journal, 20* (4), 253-263.	Occupational				X		X	
Christel, D. A., O'Donnell, N. H., & Bradley, L. A. (2016). Coping by crossdressing: an exploration of exercise clothing for obese heterosexual women. *Fashion and Textiles, 3* (1), 1-19.	Everyday	X	Freedom of dress by Lowe & Anspack (1973, 1978) and Lowe & Buckley (1982)	X	X		X	
Coca, A., Williams, W. J., Roberge, R. J., & Powell, J. B. (2010). Effects of fire fighter protective ensembles on mobility and performance. *Appled Ergonomics, 41* (4), 636-641.	Occupational							
Crown, E. M., Ackerman, M. Y., Dale, J. D., & Tan, Y. (1998). Design and evaluation of thermal protective flightsuits. Part II: Instrumented mannequin evaluation. *Clothing and Textiles Research Journal, 16* (2), 79-87.	Occupational							
Crown, E. M., & Capjack, L. (2005). Flight suits for military aviators. In R. A. Scott (Ed.), *Textiles for Protection* (pp. 678-698). Cambridge, UK: Woodhead Publishing Limited.	Occupational				X			
Crown, E. M., & Dale, J. D. (2005). Protection for workers in the oil and gas industries. In R. A. Scott (Ed.), *Textiles for Protection* (pp. 699-713). Cambridge, UK: Woodhead Publishing Limited.	Occupational				X		X	
Curteza, A., Cretu, V., Macovei, L., & Poboroniuc, M. (2014). Designing functional clothes for persons with locomotor disabilities. *Autex Research Journal, 14* (4), 281-289.	Review			X	X			
Dammacco, G., Turco, E., & Glogar, M. I. (2012). Design of protective clothing. In S. B. Vikusic (Ed.), *Functional Protective Textiles,* Firenze, Italy: Grado Zero Espace.	Review			X	X			
Davis, J. K., & Bishop, P. A. (2013). Impact of clothing on exercise in the heat. *Sports Med, 43* (8), 695-706.	Sport							
Dickson, M. A., & Pollack, A. (2000). Clothing and identity among female in-line skaters. *Clothing and Textiles Research Journal, 18* (2), 65-72.	Sport			X	X			X
Doriot, G. F., (1944). Environmental protection, *Proceedings of the American Philosophical Society, Philadelphia, 88* (3), 196-203	Review							
Eggleston, J. M., Bentrem, D. J., Bromberg, W. J., London, S. D., Biesecker, J. E., & Edlick, R. F. (1994). Adapative clothing for persons with mobility disorders after burn injury. *Journal of Burn Care Rehabilitation, 15* (3), 269-274.	Everyday				X			
Emerich, P. (2011). *Designing women's snowboarding clothing: Application and expansion of the FEA consumer needs model.* Unpublished Master's Thesis. Department of Design and Merchandising. Colorado State University. Fort Collins, Colorado.	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X	X	X	X	

APPENDIX B.1 – Functional Apparel Literature Review: End-User Dimension

				End-User Dimension				
Source	**End User Apparel Type**	**Framework Used**	**Name of Framework**	**Identity**	**Aesthetic Influences**	**Social or Ethical Concerns**	**Affordability**	**Brand**
Fan, J., & Tsang, H. (2008). Effect of clothing thermal properties on the thermal comfort sensation during active sports. *Textile Research Journal, 78* (2), 111-118.	Sport							
Fatima, N., & Paul, S. (2015). Assessment of clothing need of physically challenged children. *International Journal of Multidisciplinary Approach and Studies, 2* (2), 78-82.	Review			X	X			
Faust, M-E. (2014). Pregnant women: Understanding pregnant women's shape, sizing and apparel style preferences. In M-E Faust & S. Carrier (Eds.) *Designing apparel for consumers: The impact of body shape and size* . (pp. 235-272).Philadelphia, PA:Woodbridge Publishing Limited.	Everyday				X		X	X
Feather, B. L., Ford, S., & Herr, D. G. (1996). Female collegiate basketball players' perceptions about their bodies, garment fit and uniform design preferences. *Clothing and Textiles Research Journal, 14* (1), 22-29.	Sport			X	X			
Fenne, P. (2015). Protection against knives and other weapons. In R. Shishoo (Ed.), *Textiles for Sportswear* (pp. 648-677). Cambridge, UK: Woodhead Publishing Limited.	Occupational							
Fowler, D. (1999). The attributes sought in sports apparel: A rating. *Journal of Marketing Theory and Practice, 7* (4), 81-88.	Sport				X		X	X
Freeman, C. M., Kaiser, S. B., & Wingate, S. B. (1985). Perceptions of functional clothing by persons with physical disabilities: A social-cognitive framework. *Clothing and Textiles Research Journal, 4* (1), 46-52.	Everyday	X	Cognitive and Symbolic Interactionists Theories					
Ghalachyan, A., & MacGillivray, M. S. (2016). Designing headwear for women with chemotherapy-induced hair loss. *International Journal of Fashion Design, Technology and Education* , 1-11.	Medical	X	Watkins & Dunne (2015)	X	X			
Gill, S., & Prendergast. (2016). Garment fit and consumer perception of sportswear. In S. G. Hayes & P. Venkatraman (Eds.), *Materials and Technologies for Sportswear and Performance Apparel* (pp. 245-260). New York: CRC Press.	Sport			X	X			
Gon, D. P., & Paul, P. (2011). Complex garment systems to survive in outer space. *Journal of Textile and Apparel, Technology and Management, 7* (2), 1-25.	Review				X		X	
Goncu-Berk, G., & Topcuoglu, N. (2017). A healthcare wearable for chronic pain management. Design of a smart glove for rheumatoid arthritis. *The Design Journal, 20* (sup 1), S1978-S1988.	Medical	X	Design of wearables (Goncu-Berk & Topcuoglu, 2017).	X			X	
Greengrass, J. (2015). From co-design to design specifications and manufacture of apparel for the active ageing population. In J. McCann and D. Bryson (Eds.), *Textile-led design for the active ageing population* (pp. 309-328). Cambridge, UK:Woodbridge Publishing Limited.	Everyday				X			X
Gupta, D. (2011a). Design and engineering of functional clothing. *Indian Journal of Fibre & Textile Research, 36* (4), 327-335.	Review			X	X			
Gupta, D. (2011b). Functional clothing - Definition and classification. *Indian Journal of Fibre & Textile Research, 36* (4), 321-326.	Review			X	X			
Hall, M. L., & Orzada, B. T. (2013). Expressive prostheses: Meaning and significance. *Fashion Practice: The Journal of Design, Creative Process & the Fashion, 5* (1), 9-32.	Review	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X				

APPENDIX B.1 – Functional Apparel Literature Review: End-User Dimension

				End-User Dimension				
Source	**End User Apparel Type**	**Framework Used**	**Name of Framework**	**Identity**	**Aesthetic Influences**	**Social or Ethical Concerns**	**Affordability**	**Brand**
Han, F., Shin, K., & Chow, D. (2015). User-centred design approach for hydrotherapy wetsuit. *International Journal of Fashion Design, Technology and Education, 9* (1), 16-22.	Medical	X	User-Centered Design					
Havenith, G., & Heus, R. (2004). A test battery related to ergonomics of protective clothing. *Applied Ergonmics, 35* (1), 3-20.	Occupational				X			
Havenith, G., Heus, R., Lotens, W. A., (1990). Resultant clothing insulation: a function of body movement, posture, wind, clothing fit and ensemble thickness. *Ergonomics, 33* (1), 67-84.	Everyday							
Hawkins, M. (1962). Textiles and clothing for older people. *Journal of Home Economics, 54* (10), 852.	Everyday				X		X	
Hayes, M. B., Joiner, L. S., & Caudill, D. C. (1945). Analysis of work shirts and overalls. *Journal of Home Economics, 37* (2), 100-105.	Occupational						X	X
Hendley, A., & Bielby, D. D. (2012). Freedom between the lines: clothing behavior and identity work among young female soccer players. *Sport, Education and Society, 17* (4), 515-533.	Sport	X	Identity theory (Stryker, 1968)	X	X		X	
Ho, C., & Au, Y. (2016). Development of functional racing singlet for professional rowers. *International Journal of Fashion Design, Technology and Education* , 1-9.	Sport	X	Product Design Process (LaBat & Sokolowski, 1999)					
Ho, S. S., Yu, W. W., Lao, T. T., Chow, D. H., Chung, J. W., & Li, Y. (2009). Garment needs of pregnant women based on content analysis of in-depth interviews. *Journal of Clinical Nursing, 18* (17), 2426-2435.	Everyday				X			
Holmér, I. (1995). Protective clothing and heat stress. *Ergonomics, 38* (1), 166-182.	Occupational							
Holmér, I. (2006). Protective clothing in hot environments. *Industrial Health, 44* , 404-413.	Occupational			X				
Hong, Y., Zeng, X., Bruniaux, P., Curteza, A., Stelian, M., & Chen, Y. (2017). Garment opening position evaluation using kinesiological analysis of dressing activities: Case study of physically disabled people with scoliosis (PDPS). *Textile Research Journal, 88* (20), 2303-2318.	Everyday			X				
Hooper, D. R., Cook, B. M., Comstock, B. A., Szivak, T. K., Flanagan, S. D., Looney, D. P., . . . Kraemer, W. J. (2015). Synthetic garments enhance comfort, thermoregulatory response, and athletic performance compared with tradional cotton garments. *Journal of Strength and Conditioning Research, 29* (3), 700-707.	Sport							
Huck, J. (1988). Protective clothing systems: A technique for evaluating restriction of wearer mobility. *Applied Ergonomics, 19* , 185-190.	Occupational							
Huck, J., & Bonhotal, B. H. (1997). Fastener systems on apparel for hemiplegic stroke victims. *Applied Ergonmics, 28* (4), 277-282.	Medical							
Huck, J., & Kim, Y. (1997). Coveralls for grass fire fighting. *International Journal of Clothing Science and Technology, 9* (5), 346-359.	Occupational	X	DeJonge's (1984) Design process model in *Clothing: The portable environment* by Watkins (1984)				X	

APPENDIX B.1 – Functional Apparel Literature Review: End-User Dimension

				End-User Dimension				
Source	**End User Apparel Type**	**Framework Used**	**Name of Framework**	**Identity**	**Aesthetic Influences**	**Social or Ethical Concerns**	**Affordability**	**Brand**
Huck, J., Maganga, O., & Kim, J. (1997). Protective overalls: Evaluation of garment design and fit. *International Journal of Clothing Science and Technology, 9* (1), 45-61.	Occupational							
Hwasook, Y. (2013). Consumer perceptions, expectation and satisfaction levels of wear comfrot of hiking gear. *Korean Journal of Human Ecology, 22* (4), 637-650.	Everyday				X		X	X
Hwang, C., Chung, T.-L., & Sanders, E. A. (2016). Attitudes and purchase intentions for smart clothing: Examining U.S. consumers' functional, expressive, and aesthetic needs for solar-powered clothing. *Clothing and Textiles Research Journal, 34* (3), 207-222.	Everyday	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X	X	X		
Ilmarinen, R., E., T., & Korhonen, E. (1990). Design of functional work clothing for meat-cutters. *Applied Ergonmics, 21* (1), 2-6.	Occupational				X			
Jankovska D. & Park, J. (2018). A mixed-methods approach to evaluate fit and comfort of the hospital patient gown. *International Journal of Fashion Design, Technology and Education* , 1-10.	Medical			X	X			
Jin, H., & Black, C. (2012). Assessing functional and aesthetics clothing needs of young male tennis players. *International Journal of Fashion Design, Technology and Education, 5* (2), 145-150.	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X	X			X
Johnston, M., & Koo, H. (2016). Apparel design for female rock climbers: satisfactions and preferences. *International Journal of Fashion Design, Technology and Education* , 1-8.	Sport				X		X	
Jung, S., & Chun, J. (2013). Professional climbers' demand for movement functionality in pants. *The Research Journal of the Costume Culture, 21* (2), 261-271.	Sport							
Kabel, A., Dimka, J., & McBee-Black, K. (2017). Clothing-related barriers experienced by people with mobility diabilities and impairments. *Applied Ergonmics, 59* , 165-169.	Everyday			X	X		X	
Kabel, A., McBee-Black, K., & Dimka, J. (2016). Apparel-related participation barriers: Ability, adaptation and engagement. *Disability and Rehabilitation, 38* (22), 2184-2192.	Everyday	X	Universal Design	X	X		X	
Kalayci, E., Ozan Avinc, O., & Yavas, A. (2016). *Textile related extreme sky sports.* Paper presented at the Textile Science and Economy VIII: 8th International Scientific-Professional Conference, Zrenjanin, Serbia.	Sport							
Katsis, C. D., Goletsis, Y., Rigas, G., & Fotiadis, D. I. (2011). A wearable system for the affective monitoring of car racing drivers during simulated conditions. *Transportation Research Part C: Emerging Technologies, 19* (3), 541-551.	Occupational			X				
Khanna, S., & Kaur, A. (2013). Smart technology in spacesuits. *International Journal of Emerging Research in Management &Technology, 2* (10), 89-93.	Occupational							
Kidd, L. K. (2006). A case study: Creating special occasion garments for young women with special needs. *Clothing and Textiles Research Journal, 24* (2), 161-172.	Everyday			X	X			
Kim, M. Y. (2013). The development of safety and functional snowboard wear design. *Fashion & Textile Research Journal, 15* (3), 364-370.	Sport				X		X	X
Kennedy, S. J., (1945). Problems for future Quartermaster textile research. *Textile Research Journal, November* , 413-422.	Review							

APPENDIX B.1 – Functional Apparel Literature Review: End-User Dimension

				End-User Dimension				
Source	**End User Apparel Type**	**Framework Used**	**Name of Framework**	**Identity**	**Aesthetic Influences**	**Social or Ethical Concerns**	**Affordability**	**Brand**
Klingeberg, T., & Schilling, M. (2012). Mobile wearable device for long term monitoring of vital signs. *Computer Methods and Programs in Biomedicine, 106* (2), 89-96.	Everyday							
Koo, S. H. (2018). Understanding consumer preferences on mosquito-bite protective clothing. *International Journal of Clothing Science and Technology, 30* (2), 222-234.	Everyday				X			
Koo, H. S., & Huang, X. (2015). Visibility aid cycling clothing: flashing light-emitting diode (FLED) configurations. *International Journal of Clothing Science and Technology, 27* (3), 460-471	Sport				X			
Koo, H. S., Michaelson, D. M., Teel, K., Kim, D.-H., Park, H., & Park, M. (2016). Design preferences on wearable e-nose systems for diabetes. *International Journal of Clothing Science and Technology, 28* (2), 216-232.	Medical				X		X	
Koo, H. S., Teel, K. P., & Han, S. (2016). Explorations of design factors for developments of protective gardening gloves. *Clothing and Textiles Research Journal, 34* (4), 1-15.	Everyday				X			
Kratz, G., Söderback, I., Guidetti, S., Hultling, C., Rykatkin, T., & Söderström, M. (1997) Wheelchair users' experience of non-adapted and adapted clothes during sailing, quad rugby or wheel–walking. *Disability and Rehabilitation, 19* (1), 26-34	Sport			X	X			
Kwok, Y. L., Harlock, S. C., Tam, A. Y. C., & Lo, T. Y. (1997). The design and evaluation of a clothing system for use in the care of premature infants: Part I - The design of the clothing system. *Research Journal of Textiles and Apparel, 1* (1), 99-111.	Medical							
Kwok, Y. L., Harlock, S. C., Tam, A. Y. C., & Lo, T. Y. (1998). The design and evaluation of a clothing system for use in the care of premature infants: Part II - The evaluation of the clothing system. *Research Journal of Textiles and Apparel, 2* (1), 82-87.	Medical							
Kwok, Y. L., Kong, P. Y., & Fan, J. (1999). Development of swimwear for diving. *Research Journal of Textiles and Apparel, 3* (2), 27-33.	Sport				X		X	
Kwok, Y. L., Li, H. Y., Fan, J., & Wai, Y. C. (1999). A new design of surgery garments for the patients during operation. *Research Journal of Textiles and Apparel, 3* (2), 53-59.	Medical							
LaBat, K. L., Ryan, K. S., & Sanden-Will, S. (2016). Breast cancer survivors' wearable product needs and wants: a challenge to designers. *International Journal of Fashion Design, Technology and Education* , 1-12.	Medical				X			
Laing, R. M., & Sleivert, G. G. (2002). Clothing, textiles, and human performance. *Textile Progress, 32* (2), 1-122.	Everyday				X			
Lam Po Tang, S. (2015). Wearable sensors for sports performance. In R. Shishoo (Ed.), *Textiles for Sportswear* (pp. 169-196). Cambridge, UK: Woodhead Publishing Limited.	Sport				X			

APPENDIX B.1 – Functional Apparel Literature Review: End-User Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	End-User Dimension: Identity	Aesthetic Influences	Social or Ethical Concerns	Affordability	Brand
Lee, A.-L., Jeong, J.-R., & Kim, H.-E. (2009). Research on the wearing condition of functional mountaineering garments. *Journal of the Korean Society of Clothing and Textiles, 33* (12), 1935-1940.	Sport						X	X
Lee, G. R., Graziosi, D., & J., L. (2015, 12-16 July 2015). *The design and development of an extravehicular, stratospheric exploration (stratex) pressure suit.* Paper presented at the 45th International Conference on Environmental Systems, Bellevue, Washington.	Occupational							
Lee, H., Hong, K., & Lee, Y. (2017). Development of 3D patterns for functional outdoor pants based on skin length deformation during movement. *International Journal of Clothing Science and Technology, 29* (2), 148-165.	Everyday				X			
Lee, Y-J., Lee, Y-Y., & Seong, H. W. (2009). A case study on the development of designs for nurses'uniforms. *Journal of the Korean Society of Costume, 59* (10), 22-37.	Occupational					X		
Leidich, J., Maccagnano, Z., McFatter, D., Lee, G. R., & Hahn, N. (2015). *Stratex pressure suit assembly design and performance.* Paper presented at the International Conference on Environmental Systems, Bellevue, Washington.	Occupational							
Linos, E., Keiser, K., Fu, T., Colditz, G., Chen, S., & Yang, J. Y. (2011). Hat, shade, long sleeves, or sunscreen? Rethinking US sun protection messages based on their relative effectiveness. *Cancer Causes & Control, 22* (7), 1067-1071.	Everyday				X			
Lu, W. (2015). Design for ageing: A focus on China. In J. McCann and D. Bryson (Eds.), *Textile-led design for the active ageing population* (pp. 487-507). Cambridge, UK:Woodbridge Publishing Limited.	Sport				X			
MacDonald, N. M., Bua-Iam, P., & Majumder, R. K. (1994). Clothing purchase decisions and social participation: An empirical investigation of U.S. and U.K. rehabilitation clients. *Journal of Rehabilitation, July-Sept*, 44-50.	Everyday	X	Clothing Purchase Decision-Making Factors (MacDonald, Bua-Lam & Majumber, 1994)	X	X		X	
Mahoney, D. F., LaRose, S., & Mahoney, E. L. (2015). Family caregivers' perspectives on dementia-related dressing difficulties at home: The preservation of self model. *Dementia, 14* (4), 494-512.	Everyday	X	Various theories on sociology, symbolic use of dress, and dementia	X				
Makinen, H. (2005). Firefighters' protective clothing. In R. A. Scott (Ed.), *Textiles for protection* (pp. 622-647). Boca Raton, FL: Woodhead Publishing Limited.	Occupational							
Makinen, H., & Jussila, K. (2014). Cold-protective clothing: types, design and standards. In F. Wang and C. Gao (Eds.), Protective Clothing: Managing Thermal Stress (pp. 2-38). Cambridge, UK: Woodhead Publishing Limited.	Review							
Malzahn, K., Windmiller, J. R., Valdes-Ramirez, G., Schoning, M. J., & Wang, J. (2011). Wearable electrochemical sensors for in situ analysis in marine environments. *Analyst, 136* (14), 2912-2917.	Sport							
May-Plumlee, T., & Pittman, A. (2002). Surgical gown requirements capture: A design analysis case study. *Journal of Textile and Apparel, Technology and Management, 2* (2), 1-10.	Medical	X	Watkins (1995)				X	
McCann, J. (2015). Environmentally conscious fabric selection in sportswear design. In R. Shishoo (Ed.), *Textiles for Sportswear* (pp. 16-52). Cambridge, UK: Woodhead Publishing Limited.	Sport				X	X		

APPENDIX B.1 – Functional Apparel Literature Review: End-User Dimension

				End-User Dimension				
Source	**End User Apparel Type**	**Framework Used**	**Name of Framework**	**Identity**	**Aesthetic Influences**	**Social or Ethical Concerns**	**Affordability**	**Brand**
McCann, J. (2016). Sportswear design for the active ageing. *Fashion Practice: The Journal of Design, Creative Process & the Fashion, 8* (2), 234-256.	Sport			X	X			
McCann, J., Hurford, R., & Martin, A. (2005). *A design process for the development of innovative smart clothing that addresses end-user needs from technical, functional, aesthetic and cultural view points.* Paper presented at the Ninth IEEE International Symposium on Wearable Computers (ISWC'05), Osaka, Japan.	Everyday			X	X	X		
McQuerry, M., Barker, R., & DenHartog, E. (2018). Functional Design and Evaluation of Structural Firefighter Turnout Suits for Improved Thermal Comfort: Thermal Manikin and Physiological Modeling. *Clothing and Textiles Research Journal*, 36(3), 165-179.	Occupational	X	DeJonge's (1984) Design process model in *Clothing: The portable environment* by Watkins (1984)					
Michaelson, D., Teel, K., & Chattaraman, V. (2018). Assessing rock climbers' functional needs in climbing pants. *Clothing and Textiles Research Journal, 36* (4), pp. 235-250.	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)				X	X
Michaelson, D., Kim, D-E., & Ha, Y. Scuba Diver's Use of Selection Criteria for Assessing Wetsuit using FEA Model. International Journal of Costume and Fashion, 18(2).	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X	X		X	
Mitchka, J., Black, C., Heitmeyer, J., & Cloud, R. M. (2009). Problem structure perceived: Dance practicewear needs of adult female dance students. *Clothing and Textiles Research Journal, 27* (1), 31-44.	Sport	X	DeJonge's (1984) Design process model in *Clothing: The portable environment* by Watkins (1984)	X	X		X	X
Morris, K., Park, J., & Sarkar, A. (2017). Development of a nursing sports bra for physically active breastfeeding women through user-centered design. *Clothing and Textiles Research Journal, 35* (4), 290-306.	Sport	X	User-Centered Design	X	X			
Morrissey, M. P., & Rossi, R. M. (2013). Clothing systems for outdoor activities. *Textile Progress, 45* (2-3), 145-181.	Sport				X			
Motlogelwa, S. (2018). Comfort and durability in high-performance clothing. In J. McLoughlin & T. Sabir (Eds.), *High-Performance Apparel* (1st ed., pp. 209-219). Cambridge, UK: Woodhead Publishing.	Occupational					X		
Na, H.-S. (2007). Adaptive clothing designs for the individuals with special needs. *Journal of the Korean Society of Clothing and Textiles, 31* (6), 933-941.	Everyday			X	X		X	
Naesgaard, O. P., Storholmen, T. C. B., Wiggen, Ø. N., & Reitan, J. (2017). A user-centred design process of new cold-protective clothing for offshore petroleum workers operating in the Barents Sea. *Industrial Health, 55* (6), 564-574.	Occupational	X	User-Centered Design					
Nasir, S. H., Troynikov, O. & Massy-Westropp, N. (2017). Arthritis patients' experience and perception of therapeutic gloves. *International Journal of Fashion Design, Technology and Education, 11* (2), 233-242.	Medical				X			
Nayak, R., Houshyar, S., & Padhye, R. (2014) Recent trends and fiture scope in the protection and comfort of firefighters' personal protective clothing. *Fire Science Reviews, 3* (4), 1-19.	Review			X	X		X	
Newton, A. (1976). Clothing: A positive part of the rehabilitation process. *Journal of Rehabilitation, 42* (5), 18-22.	Everyday			X	X			

APPENDIX B.1 – Functional Apparel Literature Review: End-User Dimension

				End-User Dimension				
Source	**End User Apparel Type**	**Framework Used**	**Name of Framework**	**Identity**	**Aesthetic Influences**	**Social or Ethical Concerns**	**Affordability**	**Brand**
Park, H., & Hahn, K. H. Y. (2014). Perception of firefighters' turnout ensemble and level of satisfaction by body movement. *International Journal of Fashion Design, Technology and Education, 7* (2), 85-95.	Occupational			X				
Park, H., Nolli, G., Branson, D., Peksoz, S., Petrova, A., & Goad, C. (2011). Impact of wearing body armor on lower body mobility. *Clothing and Textiles Research Journal, 29* (3), 232-247.	Occupational							
Park, H., Park, J., Lin, S.-H., & Boorady, L. M. (2014). Assessment of firefighters needs for personal protective equipment. *Fashion and Textiles, 1* (8), 1-13.	Occupational							
Park, J. (2014). Development of an integrative process model for universal design and an empirical evaluation with hospital patient apparel. *International Journal of Fashion Design, Technology and Education, 7* (3), 179-188.	Medical	X	Universal design & Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X	X			
Parker, R., Vitalis, A., Walker, R., Riley, D., & Pearce, H. G. (2017). Measuring wildland fire fighter performance with wearable technology. *Appled Ergonomics, 59* (Pt A), 34-44.	Occupational							
Perkins, H. M., Crown, E. M., Rigakis, K. B., & Eggertson, B. S. (1992). Attitudes and behavioral intentions of agricultural workers toward disposable protective coveralls. *Clothing and Textiles Research Journal, 11* (1), 67-73.	Occupational	X	Fishbein-Ajzen (1980) Theory of Reasoned Action	X			X	
Perry, A., & Lee, J. (2017). Satisfaction with current martial arts' uniforms and purchase intention of new uniforms. *Fashion and Textiles, 4* (1).	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)		X			
Perry, A., Malinin, L., Sanders, E., Li, Y., & Leigh, K. (2017). Explore consumer needs and design purposes of smart clothing from designers' perspectives. *International Journal of Fashion Design, Technology and Education, 10* (3), 1-9.	Everyday				X		X	
Pompelli, J. (1998). *Dressing for independence: Adapting clothing for kids with special needs* (Vol. 1). Chesterfield, MO: Wings Way Press.	Everyday				X		X	
Power, E. J., Leaper, D. J., & Harris, J. M. (2017). Designing functional medical products for children with cancer. *International Journal of Fashion Design, Technology and Education, 10* (3), 1-6.	Medical	X	Quality Function Deployment	X	X			
Rantanen, J., Alfthan, N., Impio, J., Karinsalo, T., Malmivaara, M., Matala, R., . . . Tasanen, M. (Oct. 10-13, 2010). *Smart clothing for the arctic environment* . Paper presented at the Wearable Computers, The Fourth International Symposium, COEX, Seoul, South Korea.	Everyday							
Reddy-Best, K. L., & Harmon, J. (2015). Overweight boy's and girl's experiences with and perception of athletic clothing and its relationship to physical activity participation. *Fashion and Textiles, 2* (23), 1-16.	Sport			X	X	X		
Rosenblad-William, E. (1985). User-oriented production development applied to functional clothing design. *Applied Ergonmics, 16* (4), 279-287.	Everyday			X	X		X	
Rossi, R. (2014). Clothing for protection against heat and flames. In F. Wang and C. Gao (Eds.), *Protective Clothing: Managing Thermal Stress* (pp. 70-89). Cambridge, UK: Woodhead Publishing Limited.	Occupational							

APPENDIX B.1 – Functional Apparel Literature Review: End-User Dimension

				End-User Dimension				
Source	**End User Apparel Type**	**Framework Used**	**Name of Framework**	**Identity**	**Aesthetic Influences**	**Social or Ethical Concerns**	**Affordability**	**Brand**
Rossi, R. M. (2015). Cold weather sports clothing. In R. Shishoo (Ed.), *Textiles for Sportswear* (pp. 197-212). Cambridge, UK: Woodhead Publishing Limited.	Review				X			
Rucker, M., Anderson, E., & Kangas, A. (2000). Evaluation of standard and prototype protective garments for wildland firefighters. In C. Nelson and N. Henry III (Ed.), *Performance of protective clothing: Issues and priorities for the 21st century* (Vol. 7, pp. 546-556). West Conshohocken, PA: American Society for Testing and Materials.	Occupational							
Ruckman, J. E., Murray, R., & Choi, H. S. (1999). Engineering of clothing systems for improved thermophysiological comfort: The effect of openings. *International Journal of Clothing Science and Technology, 11* (1), 37-52.	Everyday							
Rusk, H. A., & Taylor, E. J. (1959). Functional fashions for the physically handicapped. *Journal of the American Medical Association, 169* (14), 1598-1600.	Everyday			X	X			
Rutherford-Black, C., & Khan, S. (1995). Texas tech police bicycle patrol: Encounter with a uniform. *Campus Law Enforcement Journal, 25* (6), 26-28.	Occupational			X			X	
Sarkar, A. K. (2005). Textiles for UV protection. In R. A. Scott (Ed.), *Textiles for protection* (pp. 355-377). Boca Raton, FL: Woodhead Publishing Limited.	Everyday				X			
Sau-Fun, N., Chi-Leung, H., & Lai-Fan, W. (2011). Development of medical garments and apparel for the elderly and the disabled. *Textile Progress, 43* (4), 235-285.	Medical			X	X			
Schulte, B. F. (2015). Designing garments for people with dementia: Innovative practice. *Dementia,14* (5), 691-695.	Everyday			X	X			
Schuste, J. D., & Kelly, D. H. (1974). Preferred style features in dresses for physically handicapped elderly women. *The Gerontologist, 14* (2), 106-109.	Everyday			X	X			
Scott, R. A. (2005). Military Protection. In R. A. Scott (Ed.), *Textiles for protection* (pp. 597-621). Boca Raton, FL: Woodhead Publishing Limited.	Occupational				X		X	
Shanley, L. A., Slaten, B. L., & Shanley, P. S. (1993). Military protective clothing: Implications for clothing and textiles curriculum and research. *Clothing and Textiles Research Journal, 11* (3), 55-59.	Occupational			X				
Shin, S., Smith, B., & Gaines, K. (2015). *Investigation of Therapy Clothing Products for Children with Autism Spectrum Disorders*. Paper presented at the International Textile and Apparel Association (ITAA) Annual Conference Proceedings, Santa Fe, New Mexico.	Everyday				X			
Song, R., & Stone, J. F. (2005). Shirt desings for sun protection. *Journal of Environmental Health, 67* (10), 50-56.	Everyday				X			
Sontag, M. S. (1986). Comfort dimensions of actual and ideal insulative clothing for older women. *Clothing and Textiles Research Journal, 4* (1), 9-17.	Everyday	X	Comfort Dimensions (Sontag, 1986)	X				
Sperling, L., & Karlsson, M. (1989). Clothing fasteners for long-term-care patients. *Applied Ergonmics, 20* (2), 97-104.	Medical			X	X		X	
Spitz, M. G., Johnson, W. K., Lesher, L. L., & Arcidiacono, S. (2016). Soldier hygiene issues and use of antimicrobial textiles in the military. *AATCC Journal of Research, 3* (5), 27-37.	Occupational							

APPENDIX B.1 – Functional Apparel Literature Review: End-User Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	End-User Dimension: Identity	Aesthetic Influences	Social or Ethical Concerns	Affordability	Brand
Stokes, B., & Black, C. (2012). Application of the functional, expressive and aesthetic consumer needs model: Assessing the clothing needs of adolescent girls with disabilities. *International Journal of Fashion Design, Technology and Education, 5* (3), 179-186.	Everyday	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X	X			
Stull, J. O. (2005). Civilian protection and protection of industrial workers from chemicals. In R. A. Scott (Ed.), *Textiles for protection* (pp. 296-354). Boca Raton, FL: Woodhead Publishing Limited.	Occupational				X	X	X	
Sweeney, D. H., & Taber, M. J. (2014). Cold-water immersion suits. In F. Wang and C. Gao (Eds.), *Protective Clothing: Managing Thermal Stress* (pp. 39-69). Cambridge, UK: Woodhead Publishing Limited.	Occupational							
Suh, C. (2013). A survery on the purchasing behavior and preference of mountain climbing pants for the development of women's functional ,ountain climbing pants patterns. *Journal of the Korean Society of Clothing and Textiles, 37* (1), 90-100.	Sport				X			X
Tamura, T. (2016). Climate and clothing. *Journal of the Human-Environment System, 19* (1), 1-11.	Everyday							
Tan, Y., Crown, E. M., & Capjack, L. (1998). Design and evaluation of thermal protective flightsuits. Part I: The design process and prototype development. *Clothing and Textiles Research Journal, 16* (1), 47-55.	Occupational	X	Objectifying apparel design process (Orlando, 1979)		X			
Teunissen, L. P., Wang, L.-C., Chou, S.-N., Huang, C.-h., Jou, G.-T., & Daanen, H. A. (2014). Evaluation of two cooling systems under a firefighter coverall. *Applied Ergonomics, 45* (6), 1433-1438.	Occupational							
Thompson, D. (2017). Design criteria utilised to develop prototype jackets for motorcycle riders in rural communities of Akwa Ibom State, Nigeria. *Journal of Emerging Trends in Economics and Management Sciences, 8* (3), 178-182.	Everyday			X	X		X	
Thompson, D., & Anyakoha, E. (2012). Assessment of expressive attributes of functional apparel product developed for cosmetologists in Lagos, Nigeria. *International Journal of Consumer Studies, 36* (4), 492-497.	Occupational	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X				X
Thoren, M. (1996). Systems approach to clothing for disabled users: Why is it difficult for disabled users to find suitable clothing? *Appled Ergonomics, 27* (6), 389-396.	Everyday	X	User-Oriented Product Development (Rosenblad, 1983; Dahlman, 1986) & Soft systems methodology (Checkland, 1991)	X	X		X	
Tremblay-Lutter, J. F., Crown, E. M., & Rigakis, K. B. (1996). Evaluation of functional fit of chemical protective gloves for agricultural workers. *Clothing and Textiles Research Journal, 14* (3), 216-224.	Occupational	X	Engineering anthropometry methods (Roebuck, 1975)					
Truong, Q., & Wilusz, W. (2005). Chemical and biological protection. In R. A. Scott (Ed.), *Textiles for protection* (pp. 557-596). Boca Raton, FL: Woodhead Publishing Limited.	Occupational				X		X	
Tullio-Pow, S., Schaefer, K., Zhu, R., Kolenchenko, O., & Nyhof-Young, J. (April 18-20 2011). *Sweet dreams: Needs assessment and prototype design of post-mastectomy sleepwear.* Paper presented at the The Role of Inclusive Design in Making Social Innovation Happen, London.	Everyday	X	User-Oriented Product Development (Rosenblad, 1983) & Universal Design (Story, 2001)	X	X		X	X

APPENDIX B.1 – Functional Apparel Literature Review: End-User Dimension

				End-User Dimension				
Source	**End User Apparel Type**	**Framework Used**	**Name of Framework**	**Identity**	**Aesthetic Influences**	**Social or Ethical Concerns**	**Affordability**	**Brand**
Tuteja, S., & Nigam, V. (2018). Functional clothing for individuals with special needs. *International Journal of Research, 4* (7), 963-967.	Everyday			X	X		X	
Van Wely, E. (2017). Current global standards for chemical protective clothing: How to choose the right protection for the right job? *Industrial Health, 55* , 485-499.	Review							
Varnsverry, P. (2005). Motorcyclists. In R. A. Scott (Ed.), *Textiles for protection* (pp. 714-733). Boca Raton, FL: Woodhead Publishing Limited.	Everyday							
Warden, J., & Dedmon, K., (1975). Clothing design uses style and utility. *Journal of Rehabilitation, July/August* , 17-24.	Everyday			X	X			
Wang, Y., Wu, D., Zhao, M., & Li, J. (2014). Evaluation on an ergonomic design of functional clothing for wheelchair users. *Applied Ergonmics, 45* (3), 550-555.	Everyday	X	User-Oriented Product Development (Rosenblad, 1983)	X				
Webster, J., & Roberts, J. (2011). Determining the effect of cricket leg guards on running performance. *Journal of Sports Sciences, 29* (7), 749-760.	Sport							
Wheat, K. L., & Dickson, M. A. (1999). Uniforms for collegiate female golfers: Cause for dissatisfaction and role conflict? *Clothing and Textiles Research Journal, 17* (1), 1-10.	Sport			X	X			X
Wong, W. K., Kwok, Y. L., Chan, K., & Yeung, C. Y. (1999). An investigation of physical functional design on child patients' garment. *Research Journal of Textiles and Apparel, 3* (2), 34-40.	Medical				X			
Worland, M., Black, C. & Freeman, C. (2017). Pre-purchase and post-purchase apparel satisfaction of female skiers and snowboarders. *International Journal of Fashion Design, Technology and Education, 10(* 2), 200-208.	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X	X		X	X
Yick, K. L., Lai, K. Y., Tsui, H. M., & Kwan, S. Y. (2012). Effects of design attributes on the functional performance of restraint garments for hospital patients. *Research Journal of Textiles and Apparel, 16* (4), 29-41.	Medical							
Zhang, L., & Zhao, Y. (2013). The status analysis of volleyball apparel structure design. Advanced Materials Research, 821-822, 781-785.	Sport							
Zhen Wang, W., Wang, Y., Lian Yu, S., Sun, L., Liu, J., & Min Wei, X. (2014). Design for mutual transformation between outdoor wear and camping tent. *International Journal of Clothing Science and Technology, 26* (4), 291-304.	Everyday					X	X	

APPENDIX B.2 – Functional Apparel Literature Review: Task Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Task Dimension								
				Environmental Considersations	Task Analysis	Protection	Regulations	Compliance	Equipment Interactions	Textiles	Adaptive	Wearable Technology
Ahsan, N., & Tullio-Pow, S. (2015). Functional clothing for natural disaster survivors. *Disaster Prevention and Management: An International Journal, 24* (3), 306-319.	Everyday	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X		X	X			X	X	
An, S. K., & Domina, T. (2015). Thermal comfort difference on gender under military garment system using thermal manikin. *AATCC Journal of Research, 2* (3), 1-5.	Occupational			X								
Anand, N. (2011). Pattern engineering and functional clothing. *Indian Journal of Fibre & Textile Research, 36* (4), 358-365.	Review			X		X				X		
Baig, M. M., Gholamhosseini, H., & Connolly, M. J. (2013). A comprehensive survey of wearable and wireless ECG monitoring systems for older adults. *Medical & Biological Engineering & Computing, 51* (5), 485-495.	Everyday							X				X
Barker, J., & Black, C. (2009). Ballistic vests for police officers: Using clothing comfort theory to analyse personal protective clothing. *International Journal of Fashion Design, Technology and Education, 2* (2-3), 59-69.	Occupational	X	Branson and Sweeney's Clothing Comfort Model (1991)	X	X	X		X		X		
Bechtold, T., Caven, B., & Wright, T. (2015). Sportswear for snow sports. In R. Shishoo (Ed.), *Textiles for Sportswear* (pp. 245-265). Cambridge, UK: Woodhead Publishing Limited.	Sport			X		X	X			X		X
Belkin, N. (1993). The challenge of defining the effectiveness of protective aseptic barrier, *Technical Textiles International, 2* (5), 22-24.	Occupational					X	X			X		
Bergen, M. E., Capjack, L., McConnan, L. G., & Richards, E. (1996). Design and evaluation of clothing for the neonate. *Clothing and Textiles Research Journal, 14* (4), 225-233.	Medical	X	DeJonge's (1984) Design process model in *Clothing: The portable environment* by Watkins (1984)		X	X			X	X	X	
Biswas, T. T., Infirri, R. S., Hagman, S. & Berglin, L. (2018). An assistive sleeping bag for children with autism spectrum disorder. *Fashion and Textiles, 5* (18), 1-12.	Everyday									X		X
Black, C., & Cloud, R. M. (2008). Assessing functional clothing needs of bicycle patrol officers. *International Journal of Fashion Design, Technology and Education, 1* (1), 35-42.	Occupational	X	DeJonge's (1984) Design process model in *Clothing: The portable environment* by Watkins (1984)		X	X						
Black, C., Freeman, C., & Rawlings, A. (2018) Problem-based learning: Design development of female chef's jackets, *International Journal of Fashion Design, Technology and Education, 11* (1), 123-128.	Occupational	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)		X	X				X		
Black, S., Kapsali, V., Bougourd, J., & Geesin, F. (2005). Fashion and funtion - factors affecting the design and use of protective clothing. In R. A. Scott (Ed.), *Textiles for protection* (pp. 60-89). Boca Raton, FL: Woodhead Publishing Limited.	Occupational	X		X	X	X	X			X		
Block, C. B. (1976). Functional clothing design. *Occupational Health, February*, 79-85.	Occupational			X	X	X			X	X	X	
Boorady, L. M. (2006). Impact protection equipment for female ice hockey players. *Research Journal of Textiles and Apparel, 10* (4), 67-72.	Sport				X	X						
Boorady, L. M. (2011). Functional clothing - Principles of fit. *Indian Journal of Fibre & Textile Research, 36* (4), 344-347.	Review			X	X	X			X	X	X	
Boorady, L. M., Haise, C., Rucker, M., & Ashdown, S. P. (2009). Protective clothing for pesticide applicators: A multimethod needs assessment. *Journal of Textile and Apparel, Technology and Management, 6* (2), 1-17.	Occupational			X	X	X			X	X		
Braganca, S., Castellucci, I., Gill, S., Matthias, P., Carvalho, M., & Arezes, P. (2018). Insights on the apparel needs and limitations for athletes with disabilities: The design of wheelchair rugby sports-wear. *Applied Ergonmics, 67*, 9-25.	Sport					X			X	X	X	X

APPENDIX B.2 – Functional Apparel Literature Review: Task Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Task Dimension								
				Environmental Considerations	Task Analysis	Protection	Regulations	Compliance	Equipment Interactions	Textiles	Adaptive	Wearable Technology
Brandt, B., & Cory, E. M. (1989). Garments worn by production workers in cleanrooms: A needs assessment. *Clothing and Textiles Research Journal, 7* (4), 27-34.	Occupational			X		X	X			X		
Burns, W. (2015). Experiences in the design, iterative development and evaluation of a technology-enabled garment for active ageing walkers. In J. McCann and D. Bryson (Eds.), *Textile-led design for the active ageing population* (pp. 509-533). Cambridge, UK:Woodbridge Publishing Limited.	Sport											X
Bye, E., & Hakala, L. (2005). Sailing apparel for women: A design development case study. *Clothing and Textiles Research Journal, 23* (1), 45-55.	Sport	X	Watkins (1995) & Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X	X	X				X		
Carroll, K. E., & Kincade, D. H. (2007). Inclusive design in apparel product development for working women with physical disabilities. *Family and Consumer Sciences Research Journal, 35* (4), 289-315.	Everyday	X	Inclusive design by Center for Universal Design at North Carolina State University (1997)		X					X		
Casselman-Dickson, M. A., & Damhorst, M. L. (1993). Female bicyclists and interest in dress: Validation with multiple *measures. Clothing and Textiles Research Journal, 11* (4), 7-17.	Sport	X	Solomon's Symbolic Use of Products (1983)									
Chae, M. (2017). An innovative teaching approach to product development: Creating tennis wear for female baby boomers. Fashion and Textiles, 4(13), 1-17.	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)			X				X		
Chae, M., & Evenson, S. (2014). Prototype development of golf wear for mature women. *International Journal of Fashion Design, Technology and Education, 7* (1), 2-9.	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X		X				X		
Chae, M., & Schofield-Tomschin, S. (2010). Investigation of design characteristics and regulatory requirements for snowboarding helmets. *International Journal of Fashion Design, Technology and Education, 3* (2), 89-97.	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X		X	X					
Chae, M.-H., Black, C., & Heitmeyer, J. (2006). Pre-purchase and post-purchase satisfaction and fashion involvement of female tennis wear consumers. *International Journal of Consumer Studies, 30* (1), 25-33.	Sport									X		
Chan, A. P., Guo, Y. P., Wong, F. K., Li, Y., Sun, S., & Han, X. (2015). The development of anti-heat stress clothing for construction workers in hot and humid weather. *Ergonomics*, 1-17.	Occupational	X	DeJonge's (1984) Design process model in *Clothing: The portable environment* by Watkins (1984)	X	X	X				X		
Chang, H. J., Hidges, N., & Yurchisin, J. (2014). Consumers with disabilities: A qualitative exploration of clothing selelction and use among female college students. *Clothing and Textiles Research Journal, 32* (1), 34-48.	Everyday	X	Self-efficacy Theory (Bandura, 1977)									
Chang, W.-M., Zhao, Y.-X., Guo, R.-P., Wang, Q., & Gu, X.-D. (2009). Design and study of clothing structure for people with limb disabilities. *Journal of Fiber Bioengineering and Informatics, 2* (1), 62-67.	Review					X			X	X		
Chen, X., & Chaudhry, I. (2005). Ballistic protection. In R. A. Scott (Ed.), *Textiles for Protection* (pp. 529-556). Cambridge, UK: Woodhead Publishing Limited.	Occupational					X	X			X	X	
Cho, H. S., Koo, S. M., Lee, J., Cho, H., Kang, D. H., Song, H. Y., . . . Lee, Y. J. (2011). Heart monitoring garments using textile electrodes for healthcare applications. *Journal of Medical Systems, 35* (2), 189-201.	Medical				X				X	X		X
Cho, K. (2006). Redesigning hospital gowns to enhance end users' satisfaction. *Family and Consumer Sciences Research Journal, 34* (4), 332-349.	Medical	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)						X	X		

APPENDIX B.2 – Functional Apparel Literature Review: Task Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Task Dimension								
				Environmental Considersations	Task Analysis	Protection	Regulations	Compliance	Equipment Interactions	Textiles	Adaptive	Wearable Technology
Choi, M.-S., & Ashdown, S. P. (2002). The design and testing of work clothing for female pear farmers. *Clothing and Textiles Research Journal, 20* (4), 253-263.	Occupational			X	X	X						
Christel, D. A., O'Donnell, N. H., & Bradley, L. A. (2016). Coping by crossdressing: an exploration of exercise clothing for obese heterosexual women. *Fashion and Textiles, 3* (1), 1-19.	Everyday	X	Freedom of dress by Lowe & Anspack (1973, 1978) and Lowe & Buckley (1982)									
Coca, A., Williams, W. J., Roberge, R. J., & Powell, J. B. (2010). Effects of fire fighter protective ensembles on mobility and performance. *Appled Ergonomics, 41* (4), 636-641.	Occupational				X				X			
Crown, E. M., Ackerman, M. Y., Dale, J. D., & Tan, Y. (1998). Design and evaluation of thermal protective flightsuits. Part II: Instrumented mannequin evaluation. *Clothing and Textiles Research Journal, 16* (2), 79-87.	Occupational					X				X		
Crown, E. M., & Capjack, L. (2005). Flight suits for military aviators. In R. A. Scott (Ed.), *Textiles for Protection* (pp. 678-698). Cambridge, UK: Woodhead Publishing Limited.	Occupational			X	X	X				X		
Crown, E. M., & Dale, J. D. (2005). Protection for workers in the oil and gas industries. In R. A. Scott (Ed.), *Textiles for Protection* (pp. 699-713). Cambridge, UK: Woodhead Publishing Limited.	Occupational			X		X			X	X		
Curteza, A., Cretu, V., Macovei, L., & Poboroniuc, M. (2014). Designing functional clothes for persons with locomotor disabilities. *Autex Research Journal, 14* (4), 281-289.	Review			X					X	X	X	
Dammacco, G., Turco, E., & Glogar, M. I. (2012). Design of protective clothing. In S. B. Vikusic (Ed.), *Functional Protective Textiles,* Firenze, Italy: Grado Zero Espace.	Review			X	X	X	X		X	X	X	X
Davis, J. K., & Bishop, P. A. (2013). Impact of clothing on exercise in the heat. *Sports Med, 43* (8), 695-706.	Sport									X		
Dickson, M. A., & Pollack, A. (2000). Clothing and identity among female in-line skaters. *Clothing and Textiles Research Journal, 18* (2), 65-72.	Sport					X				X		
Doriot, G. F., (1944). Environmental protection, *Proceedings of the American Philosophical Society, Philadelphia, 88* (3), 196-203.	Review			X	X	X			X	X		
Eggleston, J. M., Bentrem, D. J., Bromberg, W. J., London, S. D., Biesecker, J. E., & Edlick, R. F. (1994). Adapative clothing for persons with mobility disorders after burn injury. *Journal of Burn Care Rehabilitation, 15* (3), 269-274.	Everyday								X	X	X	
Emerich, P. (2011). *Designing women's snowboarding clothing: Application and expansion of the FEA consumer needs model.* Unpublished Master's Thesis. Department of Design and Merchandising. Colorado State University. Fort Collins, Colorado.	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X		X	X			X	X	
Fan, J., & Tsang, H. (2008). Effect of clothing thermal properties on the thermal comfort sensation during active sports. *Textile Research Journal, 78* (2), 111-118.	Sport									X		
Fatima, N., & Paul, S. (2015). Assessment of clothing need of physically challenged children. *International Journal of Multidisciplinary Approach and Studies, 2* (2), 78-82.	Review								X	X		
Faust, M-E. (2014). Pregnant women: Understanding pregnant women's shape, sizing and apparel style preferences. In M-E Faust & S. Carrier (Eds.) *Designing apparel for consumers: The impact of body shape and size.* (pp. 235-272). Philadelphia, PA: Woodbridge Publishing Limited.	Everyday											

APPENDIX B.2 – Functional Apparel Literature Review: Task Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Task Dimension								
				Environmental Considersations	Task Analysis	Protection	Regulations	Compliance	Equipment Interactions	Textiles	Adaptive	Wearable Technology
Feather, B. L., Ford, S., & Herr, D. G. (1996). Female collegiate basketball players' perceptions about their bodies, garment fit and uniform design preferences. *Clothing and Textiles Research Journal, 14* (1), 22-29.	Sport											
Fenne, P. (2015). Protection against knives and other weapons. In R. Shishoo (Ed.), *Textiles for Sportswear* (pp. 648-677). Cambridge, UK: Woodhead Publishing Limited.	Occupational					X	X			X		
Fowler, D. (1999). The attributes sought in sports apparel: A rating. *Journal of Marketing Theory and Practice, 7* (4), 81-88.	Sport											
Freeman, C. M., Kaiser, S. B., & Wingate, S. B. (1985). Perceptions of functional clothing by persons with physical disabilities: A social-cognitive framework. *Clothing and Textiles Research Journal, 4* (1), 46-52.	Everyday	X	Cognitive and Symbolic Interactionists Theories									
Ghalachyan, A., & MacGillivray, M. S. (2016). Designing headwear for women with chemotherapy-induced hair loss. *International Journal of Fashion Design, Technology and Education*, 1-11	Medical	X	Watkins & Dunne (2015)			X				X		
Gill, S., & Prendergast. (2016). Garment fit and consumer perception of sportswear. In S. G. Hayes & P. Venkatraman (Eds.), *Materials and Technoligies for Sportswear and Performance Apparel* (pp. 245-260). New York: CRC Press.	Sport			X	X					X		
Gon, D. P., & Paul, P. (2011). Complex garment systems to survive in outer space. *Journal of Textile and Apparel, Technology and Management, 7* (2), 1-25	Review			X		X				X		X
Goncu-Berk, G., & Topcuoglu, N. (2017). A healthcare wearable for chronic pain management. Design of a smart glove for rheumatoid arthritis. *The Design Journal, 20* (sup 1), S1978-S1988	Medical	X	Design of wearables (Goncu-Berk & Topcuoglu, 2017).							X		X
Greengrass, J. (2015). From co-design to design specifications and manufacture of apparel for the active ageing population. In J. McCann and D. Bryson (Eds.), *Textile-led design for the active ageing population* (pp. 309-328). Cambridge, UK: Woodbridge Publishing Limited	Everyday					X				X		X
Gupta, D. (2011a). Design and engineering of functional clothing. *Indian Journal of Fibre & Textile Research, 36* (4), 327-335	Review			X		X			X	X		X
Gupta, D. (2011b). Functional clothing - Definition and classification. *Indian Journal of Fibre & Textile Research, 36* (4), 321-326.	Review			X	X	X			X	X		X
Hall, M. L., & Orzada, B. T. (2013). Expressive prostheses: Meaning and significance. *Fashion Practice: The Journal of Design, Creative Process & the Fashion, 5* (1), 9-32	Review	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)									
Han, F., Shin, K., & Chow, D. (2015). User-centred design approach for hydrotherapy wetsuit. *International Journal of Fashion Design, Technology and Education, 9* (1), 16-22	Medical	X	User-Centered Design	X		X			X	X	X	
Havenith, G., & Heus, R. (2004). A test battery related to ergonomics of protective clothing. *Applied Ergonmics, 35* (1), 3-20	Occupational			X	X	X	X		X	X		
Havenith, G., Heus, R., Lotens, W. A., (1990). Resultant clothing insulation: a function of body movement, posture, wind, clothing fit and ensemble thickness. *Ergonomics, 33* (1), 67-84.	Everyday			X	X	X						
Hawkins, M. (1962). Textiles and clothing for older people. *Journal of Home Economics, 54* (10), 852	Everyday					X				X		
Hayes, M. B., Joiner, L. S., & Caudill, D. C. (1945). Analysis of work shirts and overalls. *Journal of Home Economics, 37* (2), 100-105.	Occupational						X			X		

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Source	End User Apparel Type	Framework Used	Name of Framework	Task Dimension								
				Environmental Considerations	Task Analysis	Protection	Regulations	Compliance	Equipment Interactions	Textiles	Adaptive	Wearable Technology
Hendley, A., & Bielby, D. D. (2012). Freedom between the lines: clothing behavior and identity work among young female soccer players. *Sport, Education and Society, 17* (4), 515-533.	Sport	X	Identity theory (Stryker, 1968)									
Ho, C., & Au, Y. (2016). Development of functional racing singlet for professional rowers. *International Journal of Fashion Design, Technology and Education* , 1-9.	Sport	X	Product Design Process (LaBat & Sokolowski, 1999)		X		X			X		
Ho, S. S., Yu, W. W., Lao, T. T., Chow, D. H., Chung, J. W., & Li, Y. (2009). Garment needs of pregnant women based on content analysis of in-depth interviews. *Journal of Clinical Nursing, 18* (17), 2426-2435.	Everyday				X	X				X		
Holmér, I. (1995). Protective clothing and heat stress. *Ergonomics, 38* (1), 166-182.	Occupational			X		X				X		
Holmér, I. (2006). Protective clothing in hot environments. *Industrial Health, 44* , 404-413.	Occupational			X	X	X				X		
Hong, Y., Zeng, X., Bruniaux, P., Curteza, A., Stelian, M., & Chen, Y. (2017). Garment opening position evaluation using kinesiological analysis of dressing activities: Case study of physically disabled people with scoliosis (PDPS). *Textile Research Journal, 88* (20), 2303-2318.	Everyday				X					X		
Hooper, D. R., Cook, B. M., Comstock, B. A., Szivak, T. K., Flanagan, S. D., Looney, D. P., . . . Kraemer, W. J. (2015). Synthetic garments enhance comfort, thermoregulatory response, and athletic performance compared with tradional cotton garments. *Journal of Strength and Conditioning Research, 29* (3), 700-707.	Sport			X						X		
Huck, J. (1988). Protective clothing systems: A technique for evaluating restriction of wearer mobility. *Applied Ergonomics, 19* , 185-190.	Occupational				X	X				X		
Huck, J., & Bonhotal, B. H. (1997). Fastener systems on apparel for hemiplegic stroke victims. *Applied Ergonmics, 28* (4), 277-282.	Medical										X	
Huck, J., & Kim, Y. (1997). Coveralls for grass fire fighting. *International Journal of Clothing Science and Technology, 9* (5), 346-359.	Occupational	X	DeJonge's (1984) Design process model in *Clothing: The portable environment* by Watkins (1984)	X	X	X	X		X	X		
Huck, J., Maganga, O., & Kim, J. (1997). Protective overalls: Evaluation of garment design and fit. *International Journal of Clothing Science and Technology, 9* (1), 45-61.	Occupational			X	X	X			X	X		
Hwasook, Y. (2013). Consumer perceptions, expectation and satisfaction levels of wear comfrot of hiking gear. *Korean Journal of Human Ecology, 22* (4), 637-650.	Everyday									X		
Hwang, C., Chung, T.-L., & Sanders, E. A. (2016). Attitudes and purchase intentions for smart clothing: Examining U.S. consumers' functional, expressive, and aesthetic needs for solar-powered clothing. *Clothing and Textiles Research Journal, 34* (3), 207-222.	Everyday	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X								X
Ilmarinen, R., E., T., & Korhonen, E. (1990). Design of functional work clothing for meat-cutters. *Applied Ergonmics, 21* (1), 2-6.	Occupational			X	X	X	X			X		
Jankovska D. & Park, J. (2018). A mixed-methods approach to evaluate fit and comfort of the hospital patient gown. *International Journal of Fashion Design, Technology and Education* , 1-10.	Medical			X	X					X	X	
Jin, H., & Black, C. (2012). Assessing functional and aesthetics clothing needs of young male tennis players. *International Journal of Fashion Design, Technology and Education, 5* (2), 145-150.	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)		X					X		

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Source	End User Apparel Type	Framework Used	Name of Framework	Task Dimension								
				Environmental Considerations	Task Analysis	Protection	Regulations	Compliance	Equipment Interactions	Textiles	Adaptive	Wearable Technology
Johnston, M., & Koo, H. (2016). Apparel design for female rock climbers: satisfactions and preferences. *International Journal of Fashion Design, Technology and Education*, 1-8.	Sport					X			X	X		
Jung, S., & Chun, J. (2013). Professional climbers' demand for movement functionality in pants. *The Research Journal of the Costume Culture, 21* (2), 261-271.	Sport					X				X		
Kabel, A., Dimka, J., & McBee-Black, K. (2017). Clothing-related barriers experienced by people with mobility diabilities and impairments. *Applied Ergonmics, 59*, 165-169.	Everyday					X			X		X	
Kabel, A., McBee-Black, K., & Dimka, J. (2016). Apparel-related participation barriers: Ability, adaptation and engagement. *Disability and Rehabilitation, 38* (22), 2184-2192.	Everyday	X	Universal Design	X						X	X	X
Kalayci, E., Ozan Avinc, O., & Yavas, A. (2016). *Textile related extreme sky sports.* Paper presented at the Textile Science and Economy VIII: 8th International Scientific-Professional Conference, Zrenjanin, Serbia.	Sport			X		X				X		
Katsis, C. D., Goletsis, Y., Rigas, G., & Fotiadis, D. I. (2011). A wearable system for the affective monitoring of car racing drivers during simulated conditions. *Transportation Research Part C: Emerging Technologies, 19* (3), 541-551.	Occupational			X								X
Khanna, S., & Kaur, A. (2013). Smart technology in spacesuits. *International Journal of Emerging Research in Management &Technology, 2* (10), 89-93.	Occupational			X		X			X	X		X
Kidd, L. K. (2006). A case study: Creating special occasion garments for young women with special needs. *Clothing and Textiles Research Journal, 24* (2), 161-172.	Everyday								X		X	
Kim, M. Y. (2013). The development of safety and functional snowboard wear design. *Fashion & Textile Research Journal, 15* (3), 364-370.	Sport			X		X	X			X		
Kennedy, S. J., (1945). Problems for future Quartermaster textile research. *Textile Research Journal, November*, 413-422.	Review			X		X				X		
Klingeberg, T., & Schilling, M. (2012). Mobile wearable device for long term monitoring of vital signs. *Computer Methods and Programs in Biomedicine, 106* (2), 89-96.	Everyday			X								X
Koo, S. H. (2018). Understanding consumer preferences on mosquito-bite protective clothing. *International Journal of Clothing Science and Technology, 30* (2), 222-234.	Everyday			X		X				X		X
Koo, H. S., & Huang, X. (2015). Visibility aid cycling clothing: flashing light-emitting diode (FLED) configurations. *International Journal of Clothing Science and Technology, 27* (3), 460-471	Sport					X						
Koo, H. S., Michaelson, D. M., Teel, K., Kim, D.-H., Park, H., & Park, M. (2016). Design preferences on wearable e-nose systems for diabetes. *International Journal of Clothing Science and Technology, 28* (2), 216-232.	Medical					X						X
Koo, H. S., Teel, K. P., & Han, S. (2016). Explorations of design factors for developments of protective gardening gloves. *Clothing and Textiles Research Journal, 34* (4), 1-15.	Everyday			X		X				X		
Kratz, G., Söderback, I., Guidetti, S., Hultling, C., Rykatkin, T., & Söderström, M. (1997) Wheelchair users' experience of non-adapted and adapted clothes during sailing, quad rugby or wheel-walking. *Disability and Rehabilitation, 19* (1), 26-34.	Sport			X					X	X	X	

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Source	End User Apparel Type	Framework Used	Name of Framework	Task Dimension								
				Environmental Considersations	Task Analysis	Protection	Regulations	Compliance	Equipment Interactions	Textiles	Adaptive	Wearable Technology
Kwok, Y. L., Harlock, S. C., Tam, A. Y. C., & Lo, T. Y. (1997). The design and evaluation of a clothing system for use in the care of premature infants: Part I - The design of the clothing system. *Research Journal of Textiles and Apparel, 1* (1), 99-111.	Medical								X	X	X	
Kwok, Y. L., Harlock, S. C., Tam, A. Y. C., & Lo, T. Y. (1998). The design and evaluation of a clothing system for use in the care of premature infants: Part II - The evaluation of the clothing system. *Research Journal of Textiles and Apparel, 2* (1), 82-87.	Medical											
Kwok, Y. L., Kong, P. Y., & Fan, J. (1999). Development of swimwear for diving. *Research Journal of Textiles and Apparel, 3* (2), 27-33.	Sport			X		X				X		
Kwok, Y. L., Li, H. Y., Fan, J., & Wai, Y. C. (1999). A new design of surgery garments for the patients during operation. *Research Journal of Textiles and Apparel, 3* (2), 53-59.	Medical			X						X		
LaBat, K. L., Ryan, K. S., & Sanden-Will, S. (2016). Breast cancer survivors' wearable product needs and wants: a challenge to designers. *International Journal of Fashion Design, Technology and Education*, 1-12.	Medical								X	X		
Laing, R. M., & Sleivert, G. G. (2002). Clothing, textiles, and human performance. *Textile Progress, 32* (2), 1-122.	Everyday			X		X				X		
Lam Po Tang, S. (2015). Wearable sensors for sports performance. In R. Shishoo (Ed.), *Textiles for Sportswear* (pp. 169-196). Cambridge, UK: Woodhead Publishing Limited.	Sport			X	X	X			X	X		X
Lee, A.-L., Jeong, J.-R., & Kim, H.-E. (2009). Research on the wearing condition of functional mountaineering garments. *Journal of the Korean Society of Clothing and Textiles, 33* (12), 1935-1940.	Sport			X						X		
Lee, G. R., Graziosi, D., & J., L. (2015, 12-16 July 2015). *The design and development of an extravehicular, stratospheric exploration (stratex) pressure suit.* Paper presented at the 45th International Conference on Environmental Systems, Bellevue, Washington.	Occupational			X	X	X			X			X
Lee, H., Hong, K., & Lee, Y. (2017). Development of 3D patterns for functional outdoor pants based on skin length deformation during movement. *International Journal of Clothing Science and Technology, 29* (2), 148-165.	Everyday				X							
Lee, Y-J., Lee, Y-Y., & Seong, H. W. (2009). A case study on the development of designs for nurses'uniforms. *Journal of the Korean Society of Costume, 59* (10), 22-37.	Occupational									X		
Leidich, J., Maccagnano, Z., McFatter, D., Lee, G. R., & Hahn, N. (2015). *Stratex pressure suit assembly design and performance.* Paper presented at the International Conference on Environmental Systems, Bellevue, Washington.	Occupational			X	X	X			X			X
Linos, E., Keiser, K., Fu, T., Colditz, G., Chen, S., & Yang, J. Y. (2011). Hat, shade, long sleeves, or sunscreen? Rethinking US sun protection messages based on their relative effectiveness. *Cancer Causes & Control, 22* (7), 1067-1071.	Everyday			X		X						
Lu, W. (2015). Design for ageing: A focus on China. In J. McCann and D. Bryson (Eds.), *Textile-led design for the active ageing population* (pp. 487-507). Cambridge, UK:Woodbridge Publishing Limited.	Sport									X		
MacDonald, N. M., Bua-Iam, P., & Majumder, R. K. (1994). Clothing purchase decisions and social participation: An empirical investigation of U.S. and U.K. rehabilitation clients. *Journal of Rehabilitation, July-Sept*, 44-50.	Everyday	X	Clothing Purchase Decision-Making Factors (MacDonald, Bua-Lam & Majumder, 1994)			X				X		

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Source	End User Apparel Type	Framework Used	Name of Framework	Task Dimension								
				Environmental Considersations	Task Analysis	Protection	Regulations	Compliance	Equipment Interactions	Textiles	Adaptive	Wearable Technology
Mahoney, D. F., LaRose, S., & Mahoney, E. L. (2015). Family caregivers' perspectives on dementia-related dressing difficulties at home: The preservation of self model. *Dementia, 14* (4), 494-512.	Everyday	X	Various theories on sociology, symbolic use of dress, and dementia								X	
Makinen, H. (2005). Firefighters' protective clothing. In R. A. Scott (Ed.), *Textiles for protection* (pp. 622-647). Boca Raton, FL: Woodhead Publishing Limited.	Occupational			X	X	X	X		X	X		X
Makinen, H., & Jussila, K. (2014). Cold-protective clothing: types, design and standards. In F. Wang and C. Gao (Eds.), Protective Clothing: Managing Thermal Stress (pp. 2-38). Cambridge, UK: Woodhead Publishing Limited.	Review			X	X	X	X		X	X		
Malzahn, K., Windmiller, J. R., Valdes-Ramirez, G., Schoning, M. J., & Wang, J. (2011). Wearable electrochemical sensors for in situ analysis in marine environments. *Analyst, 136* (14), 2912-2917.	Sport			X		X						X
May-Plumlee, T., & Pittman, A. (2002). Surgical gown requirements capture: A design analysis case study. *Journal of Textile and Apparel, Technology and Management, 2* (2), 1-10.	Medical	X	Watkins (1995)	X	X	X	X	X		X		
McCann, J. (2015). Environmentally conscious fabric selection in sportswear design. In R. Shishoo (Ed.), *Textiles for Sportswear* (pp. 16-52). Cambridge, UK: Woodhead Publishing Limited.	Sport			X		X				X		X
McCann, J. (2016). Sportswear design for the active ageing. *Fashion Practice: The Journal of Design, Creative Process & the Fashion, 8* (2), 234-256.	Sport									X		X
McCann, J., Hurford, R., & Martin, A. (2005). *A design process for the development of innovative smart clothing that addresses end-user needs from technical, functional, aesthetic and cultural view points.* Paper presented at the Ninth IEEE International Symposium on Wearable Computers (ISWC'05), Osaka, Japan.	Everyday			X	X	X			X	X		X
McQuerry, M., Barker, R., & DenHartog, E. (2018). Functional Design and Evaluation of Structural Firefighter Turnout Suits for Improved Thermal Comfort: Thermal Manikin and Physiological Modeling. *Clothing and Textiles Research Journal* , 36(3), 165-179.	Occupational	X	DeJonge's (1984) Design process model in *Clothing: The portable environment* by Watkins (1984)	X	X	X	X			X		
Michaelson, D., Teel, K., & Chattaraman, V. (2018). Assessing rock climbers' functional needs in climbing pants. *Clothing and Textiles Research Journal, 36* (4), pp. 235-250.	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X		X			X	X	X	
Michaelson, D., Kim, D-E., & Ha, Y. Scuba Diver's Use of Selection Criteria for Assessing Wetsuit using FEA Model. International Journal of Costume and Fashion, 18(2).	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X		X			X			
Mitchka, J., Black, C., Heitmeyer, J., & Cloud, R. M. (2009). Problem structure perceived: Dance practicewear needs of adult female dance students. *Clothing and Textiles Research Journal, 27* (1), 31-44.	Sport	X	DeJonge's (1984) Design process model in *Clothing: The portable environment* by Watkins (1984)			X				X		
Morris, K., Park, J., & Sarkar, A. (2017). Development of a nursing sports bra for physically active breastfeeding women through user-centered design. *Clothing and Textiles Research Journal, 35* (4), 290-306.	Sport	X	User-Centered Design						X	X	X	
Morrissey, M. P., & Rossi, R. M. (2013). Clothing systems for outdoor activities. *Textile Progress, 45* (2-3), 145-181.	Sport			X		X				X		X
Motlogelwa, S. (2018). Comfort and durability in high-performance clothing. In J. McLoughlin & T. Sabir (Eds.), *High-Performance Apparel* (1st ed., pp. 209-219). Cambridge, UK: Woodhead Publishing.	Occupational			X		X	X			X		

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Source	End User Apparel Type	Framework Used	Name of Framework	Task Dimension								
				Environmental Considersations	Task Analysis	Protection	Regulations	Compliance	Equipment Interactions	Textiles	Adaptive	Wearable Technology
Na, H.-S. (2007). Adaptive clothing designs for the individuals with special needs. *Journal of the Korean Society of Clothing and Textiles, 31* (6), 933-941.	Everyday					X			X		X	
Naesgaard, O. P., Storholmen, T. C. B., Wiggen, Ø. N., & Reitan, J. (2017). A user-centred design process of new cold-protective clothing for offshore petroleum workers operating in the Barents Sea. *Industrial Health, 55* (6), 564-574.	Occupational	X	User-Centered Design	X	X	X	X		X	X		
Nasir, S. H., Troynikov, O. & Massy-Westropp, N. (2017). Arthritis patients' experience and perception of therapeutic gloves. *International Journal of Fashion Design, Technology and Education, 11* (2), 233-242.	Medical									X		
Nayak, R., Houshyar, S., & Padhye, R. (2014) Recent trends and fiture scope in the protection and comfort of firefighters' personal protective clothing. *Fire Science Reviews, 3* (4), 1-19.	Review			X		X	X		X	X		X
Newton, A. (1976). Clothing: A positive part of the rehabilitation process. *Journal of Rehabilitation, 42* (5), 18-22.	Everyday								X			
Park, H., & Hahn, K. H. Y. (2014). Perception of firefighters' turnout ensemble and level of satisfaction by body movement. *International Journal of Fashion Design, Technology and Education, 7* (2), 85-95.	Occupational				X	X			X	X		
Park, H., Nolli, G., Branson, D., Peksoz, S., Petrova, A., & Goad, C. (2011). Impact of wearing body armor on lower body mobility. *Clothing and Textiles Research Journal, 29* (3), 232-247.	Occupational				X							
Park, H., Park, J., Lin, S.-H., & Boorady, L. M. (2014). Assessment of firefighters needs for personal protective equipment. *Fashion and Textiles, 1* (8), 1-13.	Occupational			X		X	X	X	X			
Park, J. (2014). Development of an integrative process model for universal design and an empirical evaluation with hospital patient apparel. *International Journal of Fashion Design, Technology and Education, 7* (3), 179-188.	Medical	X	Universal design & Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)						X	X		
Parker, R., Vitalis, A., Walker, R., Riley, D., & Pearce, H. G. (2017). Measuring wildland fire fighter performance with wearable technology. *Appled Ergonomics, 59* (Pt A), 34-44.	Occupational			X	X							X
Perkins, H. M., Crown, E. M., Rigakis, K. B., & Eggertson, B. S. (1992). Attitudes and behavioral intentions of agricultural workers toward disposable protective coveralls. *Clothing and Textiles Research Journal, 11* (1), 67-73.	Occupational	X	Fishbein-Ajzen (1980) Theory of Reasoned Action	X		X						
Perry, A., & Lee, J. (2017). Satisfaction with current martial arts' uniforms and purchase intention of new uniforms. *Fashion and Textiles, 4* (1).	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)			X				X		
Perry, A., Malinin, L., Sanders, E., Li, Y., & Leigh, K. (2017). Explore consumer needs and design purposes of smart clothing from designers' perspectives. *International Journal of Fashion Design, Technology and Education, 10* (3), 1-9.	Everyday											X
Pompelli, J. (1998). *Dressing for independence: Adapting clothing for kids with special needs* (Vol. 1). Chesterfield, MO: Wings Way Press.	Everyday					X			X		X	
Power, E. J., Leaper, D. J., & Harris, J. M. (2017). Designing functional medical products for children with cancer. *International Journal of Fashion Design, Technology and Education, 10* (3), 1-6.	Medical	X	Quality Function Deployment			X			X			

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Source	End User Apparel Type	Framework Used	Name of Framework	Task Dimension								
				Environmental Considersations	Task Analysis	Protection	Regulations	Compliance	Equipment Interactions	Textiles	Adaptive	Wearable Technology
Rantanen, J., Alfthan, N., Impio, J., Karinsalo, T., Malmivaara, M., Matala, R., . . . Tasanen, M. (Oct. 10-13, 2010). *Smart clothing for the arctic environment*. Paper presented at the Wearable Computers, The Fourth International Symposium, COEX, Seoul, South Korea.	Everyday			X	X	X				X		X
Reddy-Best, K. L., & Harmon, J. (2015). Overweight boy's and girl's experiences with and perception of athletic clothing and its relationship to physical activity participation. *Fashion and Textiles, 2* (23), 1-16.	Sport									X		
Rosenblad-William, E. (1985). User-oriented production development applied to functional clothing design. *Applied Ergonmics, 16* (4), 279-287.	Everyday			X		X				X		
Rossi, R. (2014). Clothing for protection against heat and flames. In F. Wang and C. Gao (Eds.), *Protective Clothing: Managing Thermal Stress* (pp. 70-89). Cambridge, UK: Woodhead Publishing Limited.	Occupational			X		X	X			X		X
Rossi, R. M. (2015). Cold weather sports clothing. In R. Shishoo (Ed.), *Textiles for Sportswear* (pp. 197-212). Cambridge, UK: Woodhead Publishing Limited.	Review			X		X				X		X
Rucker, M., Anderson, E., & Kangas, A. (2000). Evaluation of standard and prototype protective garments for wildland firefighters. In C. Nelson and N. Henry III (Ed.), *Performance of protective clothing: Issues and priorities for the 21st century* (Vol. 7, pp. 546-556). West Conshohocken, PA: American Society for Testing and Materials.	Occupational			X		X				X		
Ruckman, J. E., Murray, R., & Choi, H. S. (1999). Engineering of clothing systems for improved thermophysiological comfort: The effect of openings. *International Journal of Clothing Science and Technology, 11* (1), 37-52.	Everyday			X	X					X		
Rusk, H. A., & Taylor, E. J. (1959). Functional fashions for the physically handicapped. *Journal of the American Medical Association, 169* (14), 1598-1600.	Everyday								X	X		
Rutherford-Black, C., & Khan, S. (1995). Texas tech police bicycle patrol: Encounter with a uniform. *Campus Law Enforcement Journal, 25* (6), 26-28.	Occupational			X	X	X				X		
Sarkar, A. K. (2005). Textiles for UV protection. In R. A. Scott (Ed.), *Textiles for protection* (pp. 355-377). Boca Raton, FL: Woodhead Publishing Limited.	Everyday			X		X	X	X		X		
Sau-Fun, N., Chi-Leung, H., & Lai-Fan, W. (2011). Development of medical garments and apparel for the elderly and the disabled. *Textile Progress, 43* (4), 235-285.	Medical			X		X				X	X	
Schulte, B. F. (2015). Designing garments for people with dementia: Innovative practice. *Dementia,14* (5), 691-695.	Everyday									X	X	
Schuste, J. D., & Kelly, D. H. (1974). Preferred style features in dresses for physically handicapped elderly women. *The Gerontologist, 14* (2), 106-109.	Everyday											
Scott, R. A. (2005). Military Protection. In R. A. Scott (Ed.), *Textiles for protection* (pp. 597-621). Boca Raton, FL: Woodhead Publishing Limited.	Occupational			X		X	X		X	X		
Shanley, L. A., Slaten, B. L., & Shanley, P. S. (1993). Military protective clothing: Implications for clothing and textiles curriculum and research. *Clothing and Textiles Research Journal, 11* (3), 55-59.	Occupational			X		X				X		
Shin, S., Smith, B., & Gaines, K. (2015). *Investigation of Therapy Clothing Products for Children with Autism Spectrum Disorders*. Paper presented at the International Textile and Apparel Association (ITAA) Annual Conference Proceedings, Santa Fe, New Mexico.	Everyday									X		

APPENDIX B.2 – Functional Apparel Literature Review: Task Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Task Dimension								
				Environmental Considersations	Task Analysis	Protection	Regulations	Compliance	Equipment Interactions	Textiles	Adaptive	Wearable Technology
Song, R., & Stone, J. F. (2005). Shirt desings for sun protection. *Journal of Environmental Health, 67* (10), 50-56.	Everyday			X		X				X		
Sontag, M. S. (1986). Comfort dimensions of actual and ideal insulative clothing for older women. *Clothing and Textiles Research Journal, 4* (1), 9-17.	Everyday	X	Comfort Dimensions (Sontag, 1986)	X								
Sperling, L., & Karlsson, M. (1989). Clothing fasteners for long-term-care patients. *Applied Ergonmics, 20* (2), 97-104.	Medical										X	
Spitz, M. G., Johnson, W. K., Lesher, L. L., & Arcidiacono, S. (2016). Soldier hygiene issues and use of antimicrobial textiles in the military. *AATCC Journal of Research, 3* (5), 27-37.	Occupational			X		X				X		
Stokes, B., & Black, C. (2012). Application of the functional, expressive and aesthetic consumer needs model: Assessing the clothing needs of adolescent girls with disabilities. *International Journal of Fashion Design, Technology and Education, 5* (3), 179-186.	Everyday	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)		X	X			X		X	
Stull, J. O. (2005). Civilian protection and protection of industrial workers from chemicals. In R. A. Scott (Ed.), *Textiles for protection* (pp. 296-354). Boca Raton, FL: Woodhead Publishing Limited.	Occupational			X		X	X	X		X		
Sweeney, D. H., & Taber, M. J. (2014). Cold-water immersion suits. In F. Wang and C. Gao (Eds.), *Protective Clothing: Managing Thermal Stress* (pp. 39-69). Cambridge, UK: Woodhead Publishing Limited.	Occupational			X		X	X		X			
Suh, C. (2013). A survery on the purchasing behavior and preference of mountain climbing pants for the development of women's functional ,ountain climbing pants patterns. *Journal of the Korean Society of Clothing and Textiles, 37* (1), 90-100.	Sport			X								
Tamura, T. (2016). Climate and clothing. *Journal of the Human-Environment System, 19* (1), 1-11.	Everyday			X	X							
Tan, Y., Crown, E. M., & Capjack, L. (1998). Design and evaluation of thermal protective flightsuits. Part I: The design process and prototype development. *Clothing and Textiles Research Journal, 16* (1), 47-55.	Occupational	X	Objectifying apparel design process (Orlando, 1979)	X	X	X				X	X	
Teunissen, L. P., Wang, L.-C., Chou, S.-N., Huang, C.-h., Jou, G.-T., & Daanen, H. A. (2014). Evaluation of two cooling systems under a firefighter coverall. *Applied Ergonomics, 45* (6), 1433-1438.	Occupational			X	X							
Thompson, D. (2017). Design criteria utilised to develop prototype jackets for motorcycle riders in rural communities of Akwa Ibom State, Nigeria. *Journal of Emerging Trends in Economics and Management Sciences, 8* (3), 178-182.	Everyday			X		X						
Thompson, D., & Anyakoha, E. (2012). Assessment of expressive attributes of functional apparel product developed for cosmetologists in Lagos, Nigeria. *International Journal of Consumer Studies, 36* (4), 492-497.	Occupational	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)									
Thoren, M. (1996). Systems approach to clothing for disabled users: Why is it difficult for disabled users to find suitable clothing? *Appled Ergonomics, 27* (6), 389-396.	Everyday	X	User-Oriented Product Development (Rosenblad, 1983; Dahlman, 1986) & Soft systems methodology (Checkland, 1991)								X	
Tremblay-Lutter, J. F., Crown, E. M., & Rigakis, K. B. (1996). Evaluation of functional fit of chemical protective gloves for agricultural workers. *Clothing and Textiles Research Journal, 14* (3), 216-224.	Occupational	X	Engineering anthropometry methods (Roebuck, 1975)		X	X				X		
Truong, Q., & Wilusz, W. (2005). Chemical and biological protection. In R. A. Scott (Ed.), *Textiles for protection* (pp. 557-596). Boca Raton, FL: Woodhead Publishing Limited.	Occupational			X		X	X	X		X		

APPENDIX B.2 – Functional Apparel Literature Review: Task Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Task Dimension								
				Environmental Considerations	Task Analysis	Protection	Regulations	Compliance	Equipment Interactions	Textiles	Adaptive	Wearable Technology
Tullio-Pow, S., Schaefer, K., Zhu, R., Kolenchenko, O., & Nyhof-Young, J. (April 18-20 2011). *Sweet dreams: Needs assessment and prototype design of post-mastectomy sleepwear.* Paper presented at the The Role of Inclusive Design in Making Social Innovation Happen, London.	Everyday	X	User-Oriented Product Development (Rosenblad, 1983) & Universal Design (Story, 2001)									
Tuteja, S., & Nigam, V. (2018). Functional clothing for individuals with special needs. *International Journal of Research, 4* (7), 963-967.	Everyday											
Van Wely, E. (2017). Current global standards for chemical protective clothing: How to choose the right protection for the right job? *Industrial Health, 55*, 485-499.	Review			X		X	X		X	X		
Varnsverry, P. (2005). Motorcyclists. In R. A. Scott (Ed.), *Textiles for protection* (pp. 714-733). Boca Raton, FL: Woodhead Publishing Limited.	Everyday			X	X	X	X			X		
Warden, J., & Dedmon, K., (1975). Clothing design uses style and utility. *Journal of Rehabilitation, July/August*, 17-24.	Everyday					X			X		X	
Wang, Y., Wu, D., Zhao, M., & Li, J. (2014). Evaluation on an ergonomic design of functional clothing for wheelchair users. *Applied Ergonomics, 45* (3), 550-555.	Everyday	X	User-Oriented Product Development (Rosenblad, 1983)			X			X	X	X	
Webster, J., & Roberts, J. (2011). Determining the effect of cricket leg guards on running performance. *Journal of Sports Sciences, 29* (7), 749-760.	Sport				X	X						
Wheat, K. L., & Dickson, M. A. (1999). Uniforms for collegiate female golfers: Cause for dissatisfaction and role conflict? *Clothing and Textiles Research Journal, 17* (1), 1-10.	Sport					X						
Wong, W. K., Kwok, Y. L., Chan, K., & Yeung, C. Y. (1999). An investigation of physical functional design on child patients' garment. *Research Journal of Textiles and Apparel, 3* (2), 34-40.	Medical			X		X			X		X	
Worland, M., Black, C. & Freeman, C. (2017). Pre-purchase and post-purchase apparel satisfaction of female skiers and snowboarders. *International Journal of Fashion Design, Technology and Education, 10*(2), 200-208.	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X		X				X		
Yick, K. L., Lai, K. Y., Tsui, H. M., & Kwan, S. Y. (2012). Effects of design attributes on the functional performance of restraint garments for hospital patients. *Research Journal of Textiles and Apparel, 16*(4), 29-41.	Medical										X	
Zhang, L., & Zhao, Y. (2013). The status analysis of volleyball apparel structure design. Advanced Materials Research, 821-822, 781-785.	Sport				X					X		
Zhen Wang, W., Wang, Y., Lian Yu, S., Sun, L., Liu, J., & Min Wei, X. (2014). Design for mutual transformation between outdoor wear and camping tent. *International Journal of Clothing Science and Technology, 26*(4), 291-304.	Everyday										X	
		50		96	56	113	32	7	54	125	34	34

APPENDIX B.3 – Functional Apparel Literature Review: Design Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Design Dimension								
				Fit	Body Shape	Mobility	Sensory	Durability	Comfort	Performance	Components & Closures	Don/Doff
Ahsan, N., & Tullio-Pow, S. (2015). Functional clothing for natural disaster survivors. *Disaster Prevention and Management: An International Journal, 24* (3), 306-319.	Everyday	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X							X	
An, S. K., & Domina, T. (2015). Thermal comfort difference on gender under military garment system using thermal manikin. *AATCC Journal of Research, 2* (3), 1-5.	Occupational								X	X		
Anand, N. (2011). Pattern engineering and functional clothing. *Indian Journal of Fibre & Textile Research, 36* (4), 358-365.	Review			X	X	X			X	X	X	X
Baig, M. M., Gholamhosseini, H., & Connolly, M. J. (2013). A comprehensive survey of wearable and wireless ECG monitoring systems for older adults. *Medical & Biological Engineering & Computing, 51* (5), 485-495.	Everyday								X	X		
Barker, J., & Black, C. (2009). Ballistic vests for police officers: Using clothing comfort theory to analyse personal protective clothing. *International Journal of Fashion Design, Technology and Education, 2* (2-3), 59-69.	Occupational	X	Branson and Sweeney's Clothing Comfort Model (1991)	X		X			X			X
Bechtold, T., Caven, B., & Wright, T. (2015). Sportswear for snow sports. In R. Shishoo (Ed.), *Textiles for Sportswear* (pp. 245-265). Cambridge, UK: Woodhead Publishing Limited.	Sport			X		X			X	X	X	
Belkin, N. (1993). The challenge of defining the effectiveness of protective aseptic barrier, *Technical Textiles International, 2* (5), 22-24.	Occupational							X	X	X		
Bergen, M. E., Capjack, L., McConnan, L. G., & Richards, E. (1996). Design and evaluation of clothing for the neonate. *Clothing and Textiles Research Journal, 14* (4), 225-233.	Medical	X	DeJonge's (1984) Design process model in *Clothing: The portable environment* by Watkins (1984)	X					X		X	X
Biswas, T. T., Infirri, R. S., Hagman, S. & Berglin, L. (2018). An assistive sleeping bag for children with autism spectrum disorder. *Fashion and Textiles, 5* (18), 1-12.	Everyday					X			X			
Black, C., & Cloud, R. M. (2008). Assessing functional clothing needs of bicycle patrol officers. *International Journal of Fashion Design, Technology and Education, 1* (1), 35-42.	Occupational	X	DeJonge's (1984) Design process model in *Clothing: The portable environment* by Watkins (1984)			X		X	X		X	
Black, C., Freeman, C., & Rawlings, A. (2018) Problem-based learning: Design development of female chef's jackets, *International Journal of Fashion Design, Technology and Education, 11* (1), 123-128.	Occupational	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X		X			X		X	
Black, S., Kapsali, V., Bougourd, J., & Geesin, F. (2005). Fashion and funtion - factors affecting the design and use of protective clothing. In R. A. Scott (Ed.), *Textiles for protection* (pp. 60-89). Boca Raton, FL: Woodhead Publishing Limited.	Occupational	X		X		X		X	X	X	X	
Block, C. B. (1976). Functional clothing design. *Occupational Health, February*, 79-85.	Occupational			X		X			X		X	X
Boorady, L. M. (2006). Impact protection equipment for female ice hockey players. *Research Journal of Textiles and Apparel, 10* (4), 67-72.	Sport			X		X			X		X	X
Boorady, L. M. (2011). Functional clothing - Principles of fit. *Indian Journal of Fibre & Textile Research, 36* (4), 344-347.	Review			X	X	X			X		X	X
Boorady, L. M., Haise, C., Rucker, M., & Ashdown, S. P. (2009). Protective clothing for pesticide applicators: A multimethod needs assessment. *Journal of Textile and Apparel, Technology and Management, 6* (2), 1-17.	Occupational			X		X		X	X	X		X
Braganca, S., Castellucci, I., Gill, S., Matthias, P., Carvalho, M., & Arezes, P. (2018). Insights on the apparel needs and limitations for athletes with disabilities: The design of wheelchair rugby sports-wear. *Applied Ergonmics, 67*, 9-25.	Sport			X		X		X	X	X	X	X

APPENDIX B.3 – Functional Apparel Literature Review: Design Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Design Dimension								
				Fit	Body Shape	Mobility	Sensory	Durability	Comfort	Performance	Components & Closures	Don/Doff
Brandt, B., & Cory, E. M. (1989). Garments worn by production workers in cleanrooms: A needs assessment. *Clothing and Textiles Research Journal, 7* (4), 27-34.	Occupational								X	X	X	
Burns, W. (2015). Experiences in the design, iterative development and evaluation of a technology-enabled garment for active ageing walkers. In J. McCann and D. Bryson (Eds.), *Textile-led design for the active ageing population* (pp. 509-533). Cambridge, UK:Woodbridge Publishing Limited.	Sport						X		X		X	
Bye, E., & Hakala, L. (2005). Sailing apparel for women: A design development case study. *Clothing and Textiles Research Journal, 23* (1), 45-55.	Sport	X	Watkins (1995) & Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X		X		X	X	X	X	X
Carroll, K. E., & Kincade, D. H. (2007). Inclusive design in apparel product development for working women with physical disabilities. *Family and Consumer Sciences Research Journal, 35* (4), 289-315.	Everyday	X	Inclusive design by Center for Universal Design at North Carolina State University (1997)	X		X			X		X	X
Casselman-Dickson, M. A., & Damhorst, M. L. (1993). Female bicyclists and interest in dress: Validation with multiple *measures. Clothing and Textiles Research Journal, 11* (4), 7-17.	Sport	X	Solomon's Symbolic Use of Products (1983)						X	X		
Chae, M. (2017). An innovative teaching approach to product development: Creating tennis wear for female baby boomers. Fashion and Textiles, 4(13), 1-17.	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X		X		X	X			
Chae, M., & Evenson, S. (2014). Prototype development of golf wear for mature women. *International Journal of Fashion Design, Technology and Education, 7* (1), 2-9.	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X		X			X		X	
Chae, M., & Schofield-Tomschin, S. (2010). Investigation of design characteristics and regulatory requirements for snowboarding helmets. *International Journal of Fashion Design, Technology and Education, 3* (2), 89-97.	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X					X			
Chae, M.-H., Black, C., & Heitmeyer, J. (2006). Pre-purchase and post-purchase satisfaction and fashion involvement of female tennis wear consumers. *International Journal of Consumer Studies, 30* (1), 25-33.	Sport			X					X		X	
Chan, A. P., Guo, Y. P., Wong, F. K., Li, Y., Sun, S., & Han, X. (2015). The development of anti-heat stress clothing for construction workers in hot and humid weather. *Ergonomics*, 1-17.	Occupational	X	DeJonge's (1984) Design process model in *Clothing: The portable environment* by Watkins (1984)	X		X			X	X	X	X
Chang, H. J., Hidges, N., & Yurchisin, J. (2014). Consumers with disabilities: A qualitative exploration of clothing selelction and use among female college students. *Clothing and Textiles Research Journal, 32* (1), 34-48.	Everyday	X	Self-efficacy Theory (Bandura, 1977)	X	X				X			
Chang, W.-M., Zhao, Y.-X., Guo, R.-P., Wang, Q., & Gu, X.-D. (2009). Design and study of clothing structure for people with limb disabilities. *Journal of Fiber Bioengineering and Informatics, 2* (1), 62-67.	Review								X		X	X
Chen, X., & Chaudhry, I. (2005). Ballistic protection. In R. A. Scott (Ed.), *Textiles for Protection* (pp. 529-556). Cambridge, UK: Woodhead Publishing Limited.	Occupational			X	X		X		X	X	X	
Cho, H. S., Koo, S. M., Lee, J., Cho, H., Kang, D. H., Song, H. Y., . . . Lee, Y. J. (2011). Heart monitoring garments using textile electrodes for healthcare applications. *Journal of Medical Systems, 35* (2), 189-201.	Medical			X		X				X	X	
Cho, K. (2006). Redesigning hospital gowns to enhance end users' satisfaction. *Family and Consumer Sciences Research Journal, 34* (4), 332-349.	Medical	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X		X			X		X	X

APPENDIX B.3 – Functional Apparel Literature Review: Design Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Design Dimension								
				Fit	Body Shape	Mobility	Sensory	Durability	Comfort	Performance	Components & Closures	Don/Doff
Choi, M.-S., & Ashdown, S. P. (2002). The design and testing of work clothing for female pear farmers. *Clothing and Textiles Research Journal, 20* (4), 253-263.	Occupational			X		X			X	X	X	X
Christel, D. A., O'Donnell, N. H., & Bradley, L. A. (2016). Coping by crossdressing: an exploration of exercise clothing for obese heterosexual women. *Fashion and Textiles, 3* (1), 1-19.	Everyday	X	Freedom of dress by Lowe & Anspack (1973, 1978) and Lowe & Buckley (1982)	X								
Coca, A., Williams, W. J., Roberge, R. J., & Powell, J. B. (2010). Effects of fire fighter protective ensembles on mobility and performance. *Appled Ergonomics, 41* (4), 636-641.	Occupational					X				X		
Crown, E. M., Ackerman, M. Y., Dale, J. D., & Tan, Y. (1998). Design and evaluation of thermal protective flightsuits. Part II: Instrumented mannequin evaluation. *Clothing and Textiles Research Journal, 16* (2), 79-87.	Occupational			X							X	
Crown, E. M., & Capjack, L. (2005). Flight suits for military aviators. In R. A. Scott (Ed.), *Textiles for Protection* (pp. 678-698). Cambridge, UK: Woodhead Publishing Limited.	Occupational			X		X			X	X	X	X
Crown, E. M., & Dale, J. D. (2005). Protection for workers in the oil and gas industries. In R. A. Scott (Ed.), *Textiles for Protection* (pp. 699-713). Cambridge, UK: Woodhead Publishing Limited.	Occupational			X		X		X	X	X		
Curteza, A., Cretu, V., Macovei, L., & Poboroniuc, M. (2014). Designing functional clothes for persons with locomotor disabilities. *Autex Research Journal, 14* (4), 281-289.	Review			X	X	X		X	X		X	X
Dammacco, G., Turco, E., & Glogar, M. I. (2012). Design of protective clothing. In S. B. Vikusic (Ed.), *Functional Protective Textiles*, Firenze, Italy: Grado Zero Espace.	Review			X		X		X	X		X	
Davis, J. K., & Bishop, P. A. (2013). Impact of clothing on exercise in the heat. *Sports Med, 43* (8), 695-706.	Sport			X					X			
Dickson, M. A., & Pollack, A. (2000). Clothing and identity among female in-line skaters. *Clothing and Textiles Research Journal, 18* (2), 65-72.	Sport								X	X		
Doriot, G. F., (1944). Environmental protection, *Proceedings of the American Philosophical Society, Philadelphia, 88* (3), 196-203.	Review			X		X		X	X	X	X	X
Eggleston, J. M., Bentrem, D. J., Bromberg, W. J., London, S. D., Biesecker, J. E., & Edlick, R. F. (1994). Adapative clothing for persons with mobility disorders after burn injury. *Journal of Burn Care Rehabilitation, 15* (3), 269-274.	Everyday			X				X			X	X
Emerich, P. (2011). *Designing women's snowboarding clothing: Application and expansion of the FEA consumer needs model.* Unpublished Master's Thesis. Department of Design and Merchandising. Colorado State University. Fort Collins, Colorado.	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X		X		X	X	X	X	
Fan, J., & Tsang, H. (2008). Effect of clothing thermal properties on the thermal comfort sensation during active sports. *Textile Research Journal, 78* (2), 111-118.	Sport								X			
Fatima, N., & Paul, S. (2015). Assessment of clothing need of physically challenged children. *International Journal of Multidisciplinary Approach and Studies, 2* (2), 78-82.	Review			X	X			X	X		X	X
Faust, M-E. (2014). Pregnant women: Understanding pregnant women's shape, sizing and apparel style preferences. In M-E Faust & S. Carrier (Eds.) *Designing apparel for consumers: The impact of body shape and size*. (pp. 235-272) Philadelphia, PA: Woodbridge Publishing Limited.	Everyday			X	X							

APPENDIX B.3 – Functional Apparel Literature Review: Design Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Design Dimension: Fit	Body Shape	Mobility	Sensory	Durability	Comfort	Performance	Components & Closures	Don/Doff
Feather, B. L., Ford, S., & Herr, D. G. (1996). Female collegiate basketball players' perceptions about their bodies, garment fit and uniform design preferences. *Clothing and Textiles Research Journal, 14* (1), 22-29.	Sport			X	X							
Fenne, P. (2015). Protection against knives and other weapons. In R. Shishoo (Ed.), *Textiles for Sportswear* (pp. 648-677). Cambridge, UK: Woodhead Publishing Limited.	Occupational			X		X	X			X		
Fowler, D. (1999). The attributes sought in sports apparel: A rating. *Journal of Marketing Theory and Practice, 7* (4), 81-88.	Sport			X				X	X			
Freeman, C. M., Kaiser, S. B., & Wingate, S. B. (1985). Perceptions of functional clothing by persons with physical disabilities: A social-cognitive framework. *Clothing and Textiles Research Journal, 4* (1), 46-52.	Everyday	X	Cognitive and Symbolic Interactionists Theories									
Ghalachyan, A., & MacGillivray, M. S. (2016). Designing headwear for women with chemotherapy-induced hair loss. *International Journal of Fashion Design, Technology and Education* , 1-11.	Medical	X	Watkins & Dunne (2015)	X					X		X	
Gill, S., & Prendergast. (2016). Garment fit and consumer perception of sportswear. In S. G. Hayes & P. Venkatraman (Eds.), *Materials and Technologies for Sportswear and Performance Apparel* (pp. 245-260). New York: CRC Press.	Sport			X	X	X			X	X		
Gon, D. P., & Paul, P. (2011). Complex garment systems to survive in outer space. *Journal of Textile and Apparel, Technology and Management, 7* (2), 1-25.	Review					X			X		X	X
Goncu-Berk, G., & Topcuoglu, N. (2017). A healthcare wearable for chronic pain management. Design of a smart glove for rheumatoid arthritis. *The Design Journal, 20* (sup 1), S1978-S1988.	Medical	X	Design of wearables (Goncu-Berk & Topcuoglu, 2017).	X		X			X		X	X
Greengrass, J. (2015). From co-design to design specifications and manufacture of apparel for the active ageing population. In J. McCann and D. Bryson (Eds.), *Textile-led design for the active ageing population* (pp. 309-328). Cambridge, UK:Woodbridge Publishing Limited.	Everyday			X		X			X		X	X
Gupta, D. (2011a). Design and engineering of functional clothing. *Indian Journal of Fibre & Textile Research, 36* (4), 327-335.	Review			X	X	X			X	X	X	
Gupta, D. (2011b). Functional clothing - Definition and classification. *Indian Journal of Fibre & Textile Research, 36* (4), 321-326.	Review			X	X	X			X	X	X	X
Hall, M. L., & Orzada, B. T. (2013). Expressive prostheses: Meaning and significance. *Fashion Practice: The Journal of Design, Creative Process & the Fashion, 5* (1), 9-32.	Review	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)									
Han, F., Shin, K., & Chow, D. (2015). User-centred design approach for hydrotherapy wetsuit. *International Journal of Fashion Design, Technology and Education, 9* (1), 16-22.	Medical	X	User-Centered Design	X		X			X	X	X	X
Havenith, G., & Heus, R. (2004). A test battery related to ergonomics of protective clothing. *Applied Ergonomics, 35* (1), 3-20.	Occupational			X		X			X		X	X
Havenith, G., Heus, R., Lotens, W. A., (1990). Resultant clothing insulation: a function of body movement, posture, wind, clothing fit and ensemble thickness. *Ergonomics, 33* (1), 67-84.	Everyday			X		X			X	X		
Hawkins, M. (1962). Textiles and clothing for older people. *Journal of Home Economics, 54* (10), 852.	Everyday					X			X		X	X
Hayes, M. B., Joiner, L. S., & Caudill, D. C. (1945). Analysis of work shirts and overalls. *Journal of Home Economics, 37* (2), 100-105.	Occupational							X			X	

APPENDIX B.3 – Functional Apparel Literature Review: Design Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Design Dimension								
				Fit	Body Shape	Mobility	Sensory	Durability	Comfort	Performance	Components & Closures	Don/Doff
Hendley, A., & Bielby, D. D. (2012). Freedom between the lines: clothing behavior and identity work among young female soccer players. *Sport, Education and Society, 17* (4), 515-533.	Sport	X	Identity theory (Stryker, 1968)	X					X			
Ho, C., & Au, Y. (2016). Development of functional racing singlet for professional rowers. *International Journal of Fashion Design, Technology and Education* , 1-9.	Sport	X	Product Design Process (LaBat & Sokolowski, 1999)	X		X			X	X	X	
Ho, S. S., Yu, W. W., Lao, T. T., Chow, D. H., Chung, J. W., & Li, Y. (2009). Garment needs of pregnant women based on content analysis of in-depth interviews. *Journal of Clinical Nursing, 18* (17), 2426-2435.	Everyday								X	X	X	X
Holmér, I. (1995). Protective clothing and heat stress. *Ergonomics, 38* (1), 166-182.	Occupational								X	X		
Holmér, I. (2006). Protective clothing in hot environments. *Industrial Health, 44* , 404-413.	Occupational								X			
Hong, Y., Zeng, X., Bruniaux, P., Curteza, A., Stelian, M., & Chen, Y. (2017). Garment opening position evaluation using kinesiological analysis of dressing activities: Case study of physically disabled people with scoliosis (PDPS). *Textile Research Journal, 88* (20), 2303-2318.	Everyday			X		X				X	X	X
Hooper, D. R., Cook, B. M., Comstock, B. A., Szivak, T. K., Flanagan, S. D., Looney, D. P., . . . Kraemer, W. J. (2015). Synthetic garments enhance comfort, thermoregulatory response, and athletic performance compared with tradional cotton garments. *Journal of Strength and Conditioning Research, 29* (3), 700-707.	Sport								X	X		
Huck, J. (1988). Protective clothing systems: A technique for evaluating restriction of wearer mobility. *Applied Ergonomics, 19* , 185-190.	Occupational			X		X			X		X	X
Huck, J., & Bonhotal, B. H. (1997). Fastener systems on apparel for hemiplegic stroke victims. *Applied Ergonmics, 28* (4), 277-282.	Medical										X	
Huck, J., & Kim, Y. (1997). Coveralls for grass fire fighting. *International Journal of Clothing Science and Technology, 9* (5), 346-359.	Occupational	X	DeJonge's (1984) Design process model in *Clothing: The portable environment* by Watkins (1984)	X		X			X		X	X
Huck, J., Maganga, O., & Kim, J. (1997). Protective overalls: Evaluation of garment design and fit. *International Journal of Clothing Science and Technology, 9* (1), 45-61.	Occupational			X		X			X	X		X
Hwasook, Y. (2013). Consumer perceptions, expectation and satisfaction levels of wear comfrot of hiking gear. *Korean Journal of Human Ecology, 22* (4), 637-650.	Everyday			X		X			X	X		
Hwang, C., Chung, T.-L., & Sanders, E. A. (2016). Attitudes and purchase intentions for smart clothing: Examining U.S. consumers' functional, expressive, and aesthetic needs for solar-powered clothing. *Clothing and Textiles Research Journal, 34* (3), 207-222.	Everyday	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)						X	X		
Ilmarinen, R., E., T., & Korhonen, E. (1990). Design of functional work clothing for meat-cutters. *Applied Ergonmics, 21* (1), 2-6.	Occupational					X			X		X	X
Jankovska D. & Park, J. (2018). A mixed-methods approach to evaluate fit and comfort of the hospital patient gown. *International Journal of Fashion Design, Technology and Education* , 1-10.	Medical			X		X			X			X
Jin, H., & Black, C. (2012). Assessing functional and aesthetics clothing needs of young male tennis players. *International Journal of Fashion Design, Technology and Education, 5* (2), 145-150.	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X		X			X	X		
Johnston, M., & Koo, H. (2016). Apparel design for female rock climbers: satisfactions and preferences. *International Journal of Fashion Design, Technology and Education* , 1-8.	Sport			X		X		X	X		X	

APPENDIX B.3 – Functional Apparel Literature Review: Design Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Design Dimension								
				Fit	Body Shape	Mobility	Sensory	Durability	Comfort	Performance	Components & Closures	Don/Doff
Jung, S., & Chun, J. (2013). Professional climbers' demand for movement functionality in pants. *The Research Journal of the Costume Culture, 21* (2), 261-271.	Sport			X		X		X	X			
Kabel, A., Dimka, J., & McBee-Black, K. (2017). Clothing-related barriers experienced by people with mobility diabilities and impairments. *Applied Ergonmics, 59*, 165-169.	Everyday					X			X		X	X
Kabel, A., McBee-Black, K., & Dimka, J. (2016). Apparel-related participation barriers: Ability, adaptation and engagement. *Disability and Rehabilitation, 38* (22), 2184-2192.	Everyday	X	Universal Design			X			X		X	X
Kalayci, E., Ozan Avinc, O., & Yavas, A. (2016). *Textile related extreme sky sports.* Paper presented at the Textile Science and Economy VIII: 8th International Scientific-Professional Conference, Zrenjanin, Serbia.	Sport											
Katsis, C. D., Goletsis, Y., Rigas, G., & Fotiadis, D. I. (2011). A wearable system for the affective monitoring of car racing drivers during simulated conditions. *Transportation Research Part C: Emerging Technologies, 19* (3), 541-551.	Occupational											
Khanna, S., & Kaur, A. (2013). Smart technology in spacesuits. *International Journal of Emerging Research in Management &Technology, 2* (10), 89-93.	Occupational					X	X		X			X
Kidd, L. K. (2006). A case study: Creating special occasion garments for young women with special needs. *Clothing and Textiles Research Journal, 24* (2), 161-172.	Everyday			X							X	
Kim, M. Y. (2013). The development of safety and functional snowboard wear design. *Fashion & Textile Research Journal, 15* (3), 364-370.	Sport								X			
Kennedy, S. J., (1945). Problems for future Quartermaster textile research. *Textile Research Journal, November*, 413-422.	Review					X		X	X	X	X	
Klingeberg, T., & Schilling, M. (2012). Mobile wearable device for long term monitoring of vital signs. *Computer Methods and Programs in Biomedicine, 106* (2), 89-96.	Everyday											
Koo, S. H. (2018). Understanding consumer preferences on mosquito-bite protective clothing. *International Journal of Clothing Science and Technology, 30* (2), 222-234.	Everyday											
Koo, H. S., & Huang, X. (2015). Visibility aid cycling clothing: flashing light-emitting diode (FLED) configurations. *International Journal of Clothing Science and Technology, 27* (3), 460-471	Sport						X	X	X			
Koo, H. S., Michaelson, D. M., Teel, K., Kim, D.-H., Park, H., & Park, M. (2016). Design preferences on wearable e-nose systems for diabetes. *International Journal of Clothing Science and Technology, 28* (2), 216-232.	Medical					X		X	X			X
Koo, H. S., Teel, K. P., & Han, S. (2016). Explorations of design factors for developments of protective gardening gloves. *Clothing and Textiles Research Journal, 34* (4), 1-15.	Everyday					X		X	X			X
Kratz, G., Söderback, I., Guidetti, S., Hultling, C., Rykatkin, T., & Söderström, M. (1997) Wheelchair users' experience of non-adapted and adapted clothes during sailing, quad rugby or wheel–walking. *Disability and Rehabilitation, 19* (1), 26-34.	Sport			X					X			X
Kwok, Y. L., Harlock, S. C., Tam, A. Y. C., & Lo, T. Y. (1997). The design and evaluation of a clothing system for use in the care of premature infants: Part I - The design of the clothing system. *Research Journal of Textiles and Apparel, 1* (1), 99-111.	Medical			X		X			X		X	X

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Kwok, Y. L., Harlock, S. C., Tam, A. Y. C., & Lo, T. Y. (1998). The design and evaluation of a clothing system for use in the care of premature infants: Part II - The evaluation of the clothing system. *Research Journal of Textiles and Apparel, 2* (1), 82-87	Medical								X		X	X
Kwok, Y. L., Kong, P. Y., & Fan, J. (1999). Development of swimwear for diving. *Research Journal of Textiles and Apparel, 3* (2), 27-33.	Sport			X		X			X	X	X	X
Kwok, Y. L., Li, H. Y., Fan, J., & Wai, Y. C. (1999). A new design of surgery garments for the patients during operation. *Research Journal of Textiles and Apparel, 3* (2), 53-59.	Medical								X		X	X
LaBat, K. L., Ryan, K. S., & Sanden-Will, S. (2016). Breast cancer survivors' wearable product needs and wants: a challenge to designers. *International Journal of Fashion Design, Technology and Education*, 1-12.	Medical			X	X	X		X	X		X	X
Laing, R. M., & Sleivert, G. G. (2002). Clothing, textiles, and human performance. *Textile Progress, 32* (2), 1-122.	Everyday			X	X	X	X		X	X		
Lam Po Tang, S. (2015). Wearable sensors for sports performance. In R. Shishoo (Ed.), *Textiles for Sportswear* (pp. 169-196). Cambridge, UK: Woodhead Publishing Limited.	Sport			X	X	X		X	X	X	X	
Lee, A.-L., Jeong, J.-R., & Kim, H.-E. (2009). Research on the wearing condition of functional mountaineering garments. *Journal of the Korean Society of Clothing and Textiles, 33* (12), 1935-1940.	Sport			X		X		X	X	X		X
Lee, G. R., Graziosi, D., & J., L. (2015, 12-16 July 2015). *The design and development of an extravehicular, stratospheric exploration (stratex) pressure suit.* Paper presented at the 45th International Conference on Environmental Systems, Bellevue, Washington.	Occupational					X	X		X	X		
Lee, H., Hong, K., & Lee, Y. (2017). Development of 3D patterns for functional outdoor pants based on skin length deformation during movement. *International Journal of Clothing Science and Technology, 29* (2), 148-165.	Everyday			X		X			X			
Lee, Y-J., Lee, Y-Y., & Seong, H. W. (2009). A case study on the development of designs for nurses'uniforms. *Journal of the Korean Society of Costume, 59* (10), 22-37.	Occupational											
Leidich, J., Maccagnano, Z., McFatter, D., Lee, G. R., & Hahn, N. (2015). *Stratex pressure suit assembly design and performance.* Paper presented at the International Conference on Environmental Systems, Bellevue, Washington.	Occupational					X	X		X	X	X	
Linos, E., Keiser, K., Fu, T., Colditz, G., Chen, S., & Yang, J. Y. (2011). Hat, shade, long sleeves, or sunscreen? Rethinking US sun protection messages based on their relative effectiveness. *Cancer Causes & Control, 22* (7), 1067-1071.	Everyday											
Lu, W. (2015). Design for ageing: A focus on China. In J. McCann and D. Bryson (Eds.), *Textile-led design for the active ageing population* (pp. 487-507). Cambridge, UK:Woodbridge Publishing Limited.	Sport			X	X						X	
MacDonald, N. M., Bua-Iam, P., & Majumder, R. K. (1994). Clothing purchase decisions and social participation: An empirical investigation of U.S. and U.K. rehabilitation clients. *Journal of Rehabilitation, July-Sept*, 44-50.	Everyday	X	Clothing Purchase Decision-Making Factors (MacDonald, Bua-Lam & Majumber, 1994)	X	X	X			X	X		X
Mahoney, D. F., LaRose, S., & Mahoney, E. L. (2015). Family caregivers' perspectives on dementia-related dressing difficulties at home: The preservation of self model. *Dementia, 14* (4), 494-512.	Everyday	X	Various theories on sociology, symbolic use of dress, and dementia									X

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Source	End User Apparel Type	Framework Used	Name of Framework	Design Dimension								
				Fit	Body Shape	Mobility	Sensory	Durability	Comfort	Performance	Components & Closures	Don/Doff
Makinen, H. (2005). Firefighters' protective clothing. In R. A. Scott (Ed.), *Textiles for protection* (pp. 622-647). Boca Raton, FL: Woodhead Publishing Limited.	Occupational			X	X	X	X		X	X	X	X
Makinen, H., & Jussila, K. (2014). Cold-protective clothing: types, design and standards. In F. Wang and C. Gao (Eds.), Protective Clothing: Managing Thermal Stress (pp. 2-38). Cambridge, UK: Woodhead Publishing Limited.	Review			X		X	X		X	X	X	
Malzahn, K., Windmiller, J. R., Valdes-Ramirez, G., Schoning, M. J., & Wang, J. (2011). Wearable electrochemical sensors for in situ analysis in marine environments. *Analyst, 136*(14), 2912-2917.	Sport											
May-Plumlee, T., & Pittman, A. (2002). Surgical gown requirements capture: A design analysis case study. *Journal of Textile and Apparel, Technology and Management, 2*(2), 1-10.	Medical	X	Watkins (1995)	X	X	X		X	X	X	X	X
McCann, J. (2015). Environmentally conscious fabric selection in sportswear design. In R. Shishoo (Ed.), *Textiles for Sportswear* (pp. 16-52). Cambridge, UK: Woodhead Publishing Limited.	Sport			X		X			X	X		
McCann, J. (2016). Sportswear design for the active ageing. *Fashion Practice: The Journal of Design, Creative Process & the Fashion, 8*(2), 234-256.	Sport			X		X			X		X	X
McCann, J., Hurford, R., & Martin, A. (2005). *A design process for the development of innovative smart clothing that addresses end-user needs from technical, functional, aesthetic and cultural view points.* Paper presented at the Ninth IEEE International Symposium on Wearable Computers (ISWC'05), Osaka, Japan.	Everyday			X	X	X			X		X	
McQuerry, M., Barker, R., & DenHartog, E. (2018). Functional Design and Evaluation of Structural Firefighter Turnout Suits for Improved Thermal Comfort: Thermal Manikin and Physiological Modeling. *Clothing and Textiles Research Journal*, 36(3), 165-179.	Occupational	X	DeJonge's (1984) Design process model in *Clothing: The portable environment* by Watkins (1984)			X			X		X	
Michaelson, D., Teel, K., & Chattaraman, V. (2018). Assessing rock climbers' functional needs in climbing pants. *Clothing and Textiles Research Journal, 36* (4), pp. 235-250.	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X		X		X	X		X	X
Michaelson, D., Kim, D-E., & Ha, Y. Scuba Diver's Use of Selection Criteria for Assessing Wetsuit using FEA Model. International Journal of Costume and Fashion, 18(2).	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X		X			X		X	X
Mitchka, J., Black, C., Heitmeyer, J., & Cloud, R. M. (2009). Problem structure perceived: Dance practicewear needs of adult female dance students. *Clothing and Textiles Research Journal, 27*(1), 31-44.	Sport	X	DeJonge's (1984) Design process model in *Clothing: The portable environment* by Watkins (1984)	X	X				X			
Morris, K., Park, J., & Sarkar, A. (2017). Development of a nursing sports bra for physically active breastfeeding women through user-centered design. *Clothing and Textiles Research Journal, 35* (4), 290-306.	Sport	X	User-Centered Design	X					X		X	X
Morrissey, M. P., & Rossi, R. M. (2013). Clothing systems for outdoor activities. *Textile Progress, 45*(2-3), 145-181.	Sport					X			X		X	
Motlogelwa, S. (2018). Comfort and durability in high-performance clothing. In J. McLoughlin & T. Sabir (Eds.), *High-Performance Apparel* (1st ed., pp. 209-219). Cambridge, UK: Woodhead Publishing.	Occupational			X	X	X		X	X	X	X	
Na, H.-S. (2007). Adaptive clothing designs for the individuals with special needs. *Journal of the Korean Society of Clothing and Textiles, 31* (6), 933-941.	Everyday			X		X			X		X	X

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Source	End User Apparel Type	Framework Used	Name of Framework	Design Dimension								
				Fit	Body Shape	Mobility	Sensory	Durability	Comfort	Performance	Components & Closures	Don/Doff
Naesgaard, O. P., Storholmen, T. C. B., Wiggen, Ø. N., & Reitan, J. (2017). A user-centred design process of new cold-protective clothing for offshore petroleum workers operating in the Barents Sea. *Industrial Health, 55* (6), 564-574.	Occupational	X	User-Centered Design			X	X	X	X	X	X	X
Nasir, S. H., Troynikov, O. & Massy-Westropp, N. (2017). Arthritis patients' experience and perception of therapeutic gloves. *International Journal of Fashion Design, Technology and Education, 11* (2), 233-242.	Medical								X	X		X
Nayak, R., Houshyar, S., & Padhye, R. (2014) Recent trends and fiture scope in the protection and comfort of firefighters' personal protective clothing. *Fire Science Reviews, 3* (4), 1-19.	Review			X		X		X	X	X	X	X
Newton, A. (1976). Clothing: A positive part of the rehabilitation process. *Journal of Rehabilitation, 42* (5), 18-22.	Everyday			X	X	X			X			X
Park, H., & Hahn, K. H. Y. (2014). Perception of firefighters' turnout ensemble and level of satisfaction by body movement. *International Journal of Fashion Design, Technology and Education, 7* (2), 85-95.	Occupational			X	X	X	X		X		X	X
Park, H., Nolli, G., Branson, D., Peksoz, S., Petrova, A., & Goad, C. (2011). Impact of wearing body armor on lower body mobility. *Clothing and Textiles Research Journal, 29* (3), 232-247.	Occupational					X						
Park, H., Park, J., Lin, S.-H., & Boorady, L. M. (2014). Assessment of firefighters needs for personal protective equipment. *Fashion and Textiles, 1* (8), 1-13.	Occupational			X		X	X		X	X	X	X
Park, J. (2014). Development of an integrative process model for universal design and an empirical evaluation with hospital patient apparel. *International Journal of Fashion Design, Technology and Education, 7* (3), 179-188.	Medical	X	Universal design & Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)			X			X		X	X
Parker, R., Vitalis, A., Walker, R., Riley, D., & Pearce, H. G. (2017). Measuring wildland fire fighter performance with wearable technology. *Appled Ergonomics, 59* (Pt A), 34-44.	Occupational									X		
Perkins, H. M., Crown, E. M., Rigakis, K. B., & Eggertson, B. S. (1992). Attitudes and behavioral intentions of agricultural workers toward disposable protective coveralls. *Clothing and Textiles Research Journal, 11* (1), 67-73.	Occupational	X	Fishbein-Ajzen (1980) Theory of Reasoned Action			X			X			X
Perry, A., & Lee, J. (2017). Satisfaction with current martial arts' uniforms and purchase intention of new uniforms. *Fashion and Textiles, 4* (1).	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X				X	X	X		
Perry, A., Malinin, L., Sanders, E., Li, Y., & Leigh, K. (2017). Explore consumer needs and design purposes of smart clothing from designers' perspectives. *International Journal of Fashion Design, Technology and Education, 10* (3), 1-9.	Everyday					X		X	X	X		
Pompelli, J. (1998). *Dressing for independence: Adapting clothing for kids with special needs* (Vol. 1). Chesterfield, MO: Wings Way Press.	Everyday					X		X	X		X	X
Power, E. J., Leaper, D. J., & Harris, J. M. (2017). Designing functional medical products for children with cancer. *International Journal of Fashion Design, Technology and Education, 10* (3), 1-6.	Medical	X	Quality Function Deployment	X					X		X	X
Rantanen, J., Alfthan, N., Impio, J., Karinsalo, T., Malmivaara, M., Matala, R., . . . Tasanen, M. (Oct. 10-13, 2010). *Smart clothing for the arctic environment*. Paper presented at the Wearable Computers, The Fourth International Symposium, COEX, Seoul, South Korea.	Everyday					X		X	X	X	X	X

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Source	End User Apparel Type	Framework Used	Name of Framework	Design Dimension								
				Fit	Body Shape	Mobility	Sensory	Durability	Comfort	Performance	Components & Closures	Don/Doff
Reddy-Best, K. L., & Harmon, J. (2015). Overweight boy's and girl's experiences with and perception of athletic clothing and its relationship to physical activity participation. *Fashion and Textiles, 2* (23), 1-16.	Sport			X	X							
Rosenblad-William, E. (1985). User-oriented production development applied to functional clothing design. *Applied Ergonmics, 16* (4), 279-287.	Everyday			X	X	X			X	X	X	X
Rossi, R. (2014). Clothing for protection against heat and flames. In F. Wang and C. Gao (Eds.), *Protective Clothing: Managing Thermal Stress* (pp. 70-89). Cambridge, UK: Woodhead Publishing Limited.	Occupational			X							X	
Rossi, R. M. (2015). Cold weather sports clothing. In R. Shishoo (Ed.), *Textiles for Sportswear* (pp. 197-212). Cambridge, UK: Woodhead Publishing Limited.	Review					X			X		X	
Rucker, M., Anderson, E., & Kangas, A. (2000). Evaluation of standard and prototype protective garments for wildland firefighters. In C. Nelson and N. Henry III (Ed.), *Performance of protective clothing: Issues and priorities for the 21st century* (Vol. 7, pp. 546-556). West Conshohocken, PA: American Society for Testing and Materials.	Occupational			X							X	
Ruckman, J. E., Murray, R., & Choi, H. S. (1999). Engineering of clothing systems for improved thermophysiological comfort: The effect of openings. *International Journal of Clothing Science and Technology, 11* (1), 37-52.	Everyday								X		X	
Rusk, H. A., & Taylor, E. J. (1959). Functional fashions for the physically handicapped. *Journal of the American Medical Association, 169* (14), 1598-1600.	Everyday							X	X		X	X
Rutherford-Black, C., & Khan, S. (1995). Texas tech police bicycle patrol: Encounter with a uniform. *Campus Law Enforcement Journal, 25* (6), 26-28.	Occupational			X		X	X	X	X		X	
Sarkar, A. K. (2005). Textiles for UV protection. In R. A. Scott (Ed.), *Textiles for protection* (pp. 355-377). Boca Raton, FL: Woodhead Publishing Limited.	Everyday											
Sau-Fun, N., Chi-Leung, H., & Lai-Fan, W. (2011). Development of medical garments and apparel for the elderly and the disabled. *Textile Progress, 43* (4), 235-285.	Medical								X		X	X
Schulte, B. F. (2015). Designing garments for people with dementia: Innovative practice. *Dementia,14* (5), 691-695.	Everyday					X					X	
Schuste, J. D., & Kelly, D. H. (1974). Preferred style features in dresses for physically handicapped elderly women. *The Gerontologist, 14* (2), 106-109.	Everyday					X			X			X
Scott, R. A. (2005). Military Protection. In R. A. Scott (Ed.), *Textiles for protection* (pp. 597-621). Boca Raton, FL: Woodhead Publishing Limited.	Occupational					X	X	X	X	X		
Shanley, L. A., Slaten, B. L., & Shanley, P. S. (1993). Military protective clothing: Implications for clothing and textiles curriculum and research. *Clothing and Textiles Research Journal, 11* (3), 55-59.	Occupational					X			X		X	X
Shin, S., Smith, B., & Gaines, K. (2015). *Investigation of Therapy Clothing Products for Children with Autism Spectrum Disorders*. Paper presented at the International Textile and Apparel Association (ITAA) Annual Conference Proceedings, Santa Fe, New Mexico.	Everyday			X								
Song, R., & Stone, J. F. (2005). Shirt desings for sun protection. *Journal of Environmental Health, 67* (10), 50-56.	Everyday											
Sontag, M. S. (1986). Comfort dimensions of actual and ideal insulative clothing for older women. *Clothing and Textiles Research Journal, 4* (1), 9-17.	Everyday	X	Comfort Dimensions (Sontag, 1986)						X			

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Sperling, L., & Karlsson, M. (1989). Clothing fasteners for long-term-care patients. *Applied Ergonomics, 20*(2), 97-104.	Medical								X	X	X	X
Spitz, M. G., Johnson, W. K., Lesher, L. L., & Arcidiacono, S. (2016). Soldier hygiene issues and use of antimicrobial textiles in the military. *AATCC Journal of Research, 3*(5), 27-37.	Occupational								X	X		
Stokes, B., & Black, C. (2012). Application of the functional, expressive and aesthetic consumer needs model: Assessing the clothing needs of adolescent girls with disabilities. *International Journal of Fashion Design, Technology and Education, 5*(3), 179-186.	Everyday	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X		X					X	X
Stull, J. O. (2005). Civilian protection and protection of industrial workers from chemicals. In R. A. Scott (Ed.), *Textiles for protection* (pp. 296-354). Boca Raton, FL: Woodhead Publishing Limited.	Occupational						X	X		X	X	
Sweeney, D. H., & Taber, M. J. (2014). Cold-water immersion suits. In F. Wang and C. Gao (Eds.), *Protective Clothing: Managing Thermal Stress* (pp. 39-69). Cambridge, UK: Woodhead Publishing Limited.	Occupational			X				X	X	X	X	X
Suh, C. (2013). A survey on the purchasing behavior and preference of mountain climbing pants for the development of women's functional ,ountain climbing pants patterns. *Journal of the Korean Society of Clothing and Textiles, 37*(1), 90-100.	Sport			X					X			
Tamura, T. (2016). Climate and clothing. *Journal of the Human-Environment System, 19*(1), 1-11.	Everyday								X			
Tan, Y., Crown, E. M., & Capjack, L. (1998). Design and evaluation of thermal protective flightsuits. Part I: The design process and prototype development. *Clothing and Textiles Research Journal, 16*(1), 47-55.	Occupational	X	Objectifying apparel design process (Orlando, 1979)	X		X			X	X	X	X
Teunissen, L. P., Wang, L.-C., Chou, S.-N., Huang, C.-h., Jou, G.-T., & Daanen, H. A. (2014). Evaluation of two cooling systems under a firefighter coverall. *Applied Ergonomics, 45*(6), 1433-1438.	Occupational								X	X		
Thompson, D. (2017). Design criteria utilised to develop prototype jackets for motorcycle riders in rural communities of Akwa Ibom State, Nigeria. *Journal of Emerging Trends in Economics and Management Sciences, 8*(3), 178-182.	Everyday			X	X	X	X		X		X	X
Thompson, D., & Anyakoha, E. (2012). Assessment of expressive attributes of functional apparel product developed for cosmetologists in Lagos, Nigeria. *International Journal of Consumer Studies, 36*(4), 492-497.	Occupational	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)									
Thoren, M. (1996). Systems approach to clothing for disabled users: Why is it difficult for disabled users to find suitable clothing? *Appled Ergonomics, 27*(6), 389-396.	Everyday	X	User-Oriented Product Development (Rosenblad, 1983; Dahlman, 1986) & Soft systems methodology (Checkland, 1991)						X			
Tremblay-Lutter, J. F., Crown, E. M., & Rigakis, K. B. (1996). Evaluation of functional fit of chemical protective gloves for agricultural workers. *Clothing and Textiles Research Journal, 14*(3), 216-224.	Occupational	X	Engineering anthropometry methods (Roebuck, 1975)	X		X				X		
Truong, Q., & Wilusz, W. (2005). Chemical and biological protection. In R. A. Scott (Ed.), *Textiles for protection* (pp. 557-596). Boca Raton, FL: Woodhead Publishing Limited.	Occupational					X	X	X	X		X	X
Tullio-Pow, S., Schaefer, K., Zhu, R., Kolenchenko, O., & Nyhof-Young, J. (April 18-20 2011). ***Sweet dreams: Needs assessment and prototype design of post-mastectomy sleepwear.*** Paper presented at the The Role of Inclusive Design in Making Social Innovation Happen, London.	Everyday	X	User-Oriented Product Development (Rosenblad, 1983) & Universal Design (Story, 2001)	X				X	X			

APPENDIX B.3 – Functional Apparel Literature Review: Design Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Design Dimension								
				Fit	Body Shape	Mobility	Sensory	Durability	Comfort	Performance	Components & Closures	Don/Doff
Tuteja, S., & Nigam, V. (2018). Functional clothing for individuals with special needs. *International Journal of Research, 4* (7), 963-967.	Everyday								X		X	X
Van Wely, E. (2017). Current global standards for chemical protective clothing: How to choose the right protection for the right job? *Industrial Health, 55*, 485-499.	Review			X		X	X	X	X	X	X	X
Vamsverry, P. (2005). Motorcyclists. In R. A. Scott (Ed.), *Textiles for protection* (pp. 714-733). Boca Raton, FL: Woodhead Publishing Limited.	Everyday					X	X	X	X	X		
Warden, J., & Dedmon, K., (1975). Clothing design uses style and utility. *Journal of Rehabilitation, July/August*, 17-24.	Everyday			X				X	X			
Wang, Y., Wu, D., Zhao, M., & Li, J. (2014). Evaluation on an ergonomic design of functional clothing for wheelchair users. *Applied Ergonomics, 45* (3), 550-555.	Everyday	X	User-Oriented Product Development (Rosenblad, 1983)			X			X			X
Webster, J., & Roberts, J. (2011). Determining the effect of cricket leg guards on running performance. *Journal of Sports Sciences, 29* (7), 749-760.	Sport					X				X		
Wheat, K. L., & Dickson, M. A. (1999). Uniforms for collegiate female golfers: Cause for dissatisfaction and role conflict? *Clothing and Textiles Research Journal, 17* (1), 1-10.	Sport			X				X	X	X	X	
Wong, W. K., Kwok, Y. L., Chan, K., & Yeung, C. Y. (1999). An investigation of physical functional design on child patients' garment. *Research Journal of Textiles and Apparel, 3* (2), 34-40.	Medical					X					X	X
Worland, M., Black, C. & Freeman, C. (2017). Pre-purchase and post-purchase apparel satisfaction of female skiers and snowboarders. *International Journal of Fashion Design, Technology and Education, 10(* 2), 200-208.	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X		X			X			
Yick, K. L., Lai, K. Y., Tsui, H. M., & Kwan, S. Y. (2012). Effects of design attributes on the functional performance of restraint garments for hospital patients. *Research Journal of Textiles and Apparel, 16* (4), 29-41.	Medical			X		X			X	X	X	X
Zhang, L., & Zhao, Y. (2013). The status analysis of volleyball apparel structure design. Advanced Materials Research, 821-822, 781-785.	Sport					X			X			
Zhen Wang, W., Wang, Y., Lian Yu, S., Sun, L., Liu, J., & Min Wei, X. (2014). Design for mutual transformation between outdoor wear and camping tent. *International Journal of Clothing Science and Technology, 26* (4), 291-304.	Everyday										X	
		50		106	26	108	20	45	147	71	104	81

APPENDIX B.4 – Functional Apparel Literature Review: Production Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Production Dimension				
				Sizing System	Construction	Quality	Ease of Care	Availability
Ahsan, N., & Tullio-Pow, S. (2015). Functional clothing for natural disaster survivors. *Disaster Prevention and Management: An International Journal, 24* (3), 306-319.	Everyday	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X			X	X
An, S. K., & Domina, T. (2015). Thermal comfort difference on gender under military garment system using thermal manikin. *AATCC Journal of Research, 2* (3), 1-5.	Occupational							
Anand, N. (2011). Pattern engineering and functional clothing. *Indian Journal of Fibre & Textile Research, 36* (4), 358-365.	Review				X			
Baig, M. M., Gholamhosseini, H., & Connolly, M. J. (2013). A comprehensive survey of wearable and wireless ECG monitoring systems for older adults. *Medical & Biological Engineering & Computing, 51* (5), 485-495.	Everyday							
Barker, J., & Black, C. (2009). Ballistic vests for police officers: Using clothing comfort theory to analyse personal protective clothing. *International Journal of Fashion Design, Technology and Education, 2* (2-3), 59-69.	Occupational	X	Branson and Sweeney's Clothing Comfort Model (1991)		X	X		
Bechtold, T., Caven, B., & Wright, T. (2015). Sportswear for snow sports. In R. Shishoo (Ed.), *Textiles for Sportswear* (pp. 245-265). Cambridge, UK: Woodhead Publishing Limited.	Sport				X			
Belkin, N. (1993). The challenge of defining the effectiveness of protective aseptic barrier, *Technical Textiles International, 2* (5), 22-24.	Occupational						X	
Bergen, M. E., Capjack, L., McConnan, L. G., & Richards, E. (1996). Design and evaluation of clothing for the neonate. *Clothing and Textiles Research Journal, 14* (4), 225-233.	Medical	X	DeJonge's (1984) Design process model in *Clothing: The portable environment* by Watkins (1984)	X	X			
Biswas, T. T., Infirri, R. S., Hagman, S. & Berglin, L. (2018). An assistive sleeping bag for children with autism spectrum disorder. *Fashion and Textiles, 5* (18), 1-12.	Everyday							
Black, C., & Cloud, R. M. (2008). Assessing functional clothing needs of bicycle patrol officers. *International Journal of Fashion Design, Technology and Education, 1* (1), 35-42.	Occupational	X	DeJonge's (1984) Design process model in *Clothing: The portable environment* by Watkins (1984)			X	X	
Black, C., Freeman, C., & Rawlings, A. (2018) Problem-based learning: Design development of female chef's jackets, *International Journal of Fashion Design, Technology and Education, 11* (1), 123-128.	Occupational	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)					
Black, S., Kapsali, V., Bougourd, J., & Geesin, F. (2005). Fashion and funtion - factors affecting the design and use of protective clothing. In R. A. Scott (Ed.), *Textiles for protection* (pp. 60-89). Boca Raton, FL: Woodhead Publishing Limited.	Occupational	X		X	X			X

APPENDIX B.4 – Functional Apparel Literature Review: Production Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Production Dimension				
				Sizing System	Construction	Quality	Ease of Care	Availability
Block, C. B. (1976). Functional clothing design. *Occupational Health*, *February*, 79-85.	Occupational				X			
Boorady, L. M. (2006). Impact protection equipment for female ice hockey players. *Research Journal of Textiles and Apparel, 10* (4), 67-72.	Sport			X				
Boorady, L. M. (2011). Functional clothing - Principles of fit. *Indian Journal of Fibre & Textile Research, 36* (4), 344-347.	Review			X	X			
Boorady, L. M., Haise, C., Rucker, M., & Ashdown, S. P. (2009). Protective clothing for pesticide applicators: A multimethod needs assessment. *Journal of Textile and Apparel, Technology and Management, 6* (2), 1-17.	Occupational			X				
Braganca, S., Castellucci, I., Gill, S., Matthias, P., Carvalho, M., & Arezes, P. (2018). Insights on the apparel needs and limitations for athletes with disabilities: The design of wheelchair rugby sports-wear. *Applied Ergonomics, 67*, 9-25.	Sport			X	X	X	X	X
Brandt, B., & Cory, E. M. (1989). Garments worn by production workers in cleanrooms: A needs assessment. *Clothing and Textiles Research Journal, 7* (4), 27-34.	Occupational						X	
Burns, W. (2015). Experiences in the design, iterative development and evaluation of a technology-enabled garment for active ageing walkers. In J. McCann and D. Bryson (Eds.), *Textile-led design for the active ageing population* (pp. 509-533). Cambridge, UK:Woodbridge Publishing Limited.	Sport							
Bye, E., & Hakala, L. (2005). Sailing apparel for women: A design development case study. *Clothing and Textiles Research Journal, 23* (1), 45-55.	Sport	X	Watkins (1995) & Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)		X	X		
Carroll, K. E., & Kincade, D. H. (2007). Inclusive design in apparel product development for working women with physical disabilities. *Family and Consumer Sciences Research Journal, 35* (4), 289-315.	Everyday	X	Inclusive design by Center for Universal Design at North Carolina State University (1997)		X	X		
Casselman-Dickson, M. A., & Damhorst, M. L. (1993). Female bicyclists and interest in dress: Validation with multiple *measures. Clothing and Textiles Research Journal, 11* (4), 7-17.	Sport	X	Solomon's Symbolic Use of Products (1983)					
Chae, M. (2017). An innovative teaching approach to product development: Creating tennis wear for female baby boomers. Fashion and Textiles, 4(13), 1-17.	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)					
Chae, M., & Evenson, S. (2014). Prototype development of golf wear for mature women. *International Journal of Fashion Design, Technology and Education, 7* (1), 2-9.	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)				X	

APPENDIX B.4 – Functional Apparel Literature Review: Production Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Production Dimension				
				Sizing System	Construction	Quality	Ease of Care	Availability
Crown, E. M., Ackerman, M. Y., Dale, J. D., & Tan, Y. (1998). Design and evaluation of thermal protective flightsuits. Part II: Instrumented mannequin evaluation. *Clothing and Textiles Research Journal, 16* (2), 79-87.	Occupational				X			
Crown, E. M., & Capjack, L. (2005). Flight suits for military aviators. In R. A. Scott (Ed.), *Textiles for Protection* (pp. 678-698). Cambridge, UK: Woodhead Publishing Limited.	Occupational				X		X	
Crown, E. M., & Dale, J. D. (2005). Protection for workers in the oil and gas industries. In R. A. Scott (Ed.), *Textiles for Protection* (pp. 699-713). Cambridge, UK: Woodhead Publishing Limited.	Occupational						X	
Curteza, A., Cretu, V., Macovei, L., & Poboroniuc, M. (2014). Designing functional clothes for persons with locomotor disabilities. *Autex Research Journal, 14* (4), 281-289.	Review						X	
Dammacco, G., Turco, E., & Glogar, M. I. (2012). Design of protective clothing. In S. B. Vikusic (Ed.), *Functional Protective Textiles,* Firenze, Italy: Grado Zero Espace.	Review				X			
Davis, J. K., & Bishop, P. A. (2013). Impact of clothing on exercise in the heat. *Sports Med, 43* (8), 695-706.	Sport							
Dickson, M. A., & Pollack, A. (2000). Clothing and identity among female in-line skaters. *Clothing and Textiles Research Journal, 18* (2), 65-72.	Sport							
Doriot, G. F., (1944). Environmental protection, *Proceedings of the American Philosophical Society, Philadelphia, 88* (3), 196-203	Review							
Eggleston, J. M., Bentrem, D. J., Bromberg, W. J., London, S. D., Biesecker, J. E., & Edlick, R. F. (1994). Adapative clothing for persons with mobility disorders after burn injury. *Journal of Burn Care Rehabilitation, 15* (3), 269-274	Everyday							
Emerich, P. (2011). *Designing women's snowboarding clothing: Application and expansion of the FEA consumer needs model.* Unpublished Master's Thesis. Department of Design and Merchandising. Colorado State University. Fort Collins, Colorado.	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)		X	X		X
Fan, J., & Tsang, H. (2008). Effect of clothing thermal properties on the thermal comfort sensation during active sports. *Textile Research Journal, 78* (2), 111-118.	Sport							
Fatima, N., & Paul, S. (2015). Assessment of clothing need of physically challenged children. *International Journal of Multidisciplinary Approach and Studies, 2* (2), 78-82	Review			X			X	

APPENDIX B.4 – Functional Apparel Literature Review: Production Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Production Dimension				
				Sizing System	Construction	Quality	Ease of Care	Availability
Faust, M-E. (2014). Pregnant women: Understanding pregnant women's shape, sizing and apparel style preferences. In M-E Faust & S. Carrier (Eds.) *Designing apparel for consumers: The impact of body shape and size* . (pp. 235-272).Philadelphia, PA:Woodbridge Publishing Limited.	Everyday			X		X		
Feather, B. L., Ford, S., & Herr, D. G. (1996). Female collegiate basketball players' perceptions about their bodies, garment fit and uniform design preferences. *Clothing and Textiles Research Journal, 14* (1), 22-29.	Sport			X				
Fenne, P. (2015). Protection against knives and other weapons. In R. Shishoo (Ed.), *Textiles for Sportswear* (pp. 648-677). Cambridge, UK: Woodhead Publishing Limited.	Occupational			X	X	X		
Fowler, D. (1999). The attributes sought in sports apparel: A rating. *Journal of Marketing Theory and Practice, 7* (4), 81-88.	Sport						X	
Freeman, C. M., Kaiser, S. B., & Wingate, S. B. (1985). Perceptions of functional clothing by persons with physical disabilities: A social-cognitive framework. *Clothing and Textiles Research Journal, 4* (1), 46-52.	Everyday	X	Cognitive and Symbolic Interactionists Theories					
Ghalachyan, A., & MacGillivray, M. S. (2016). Designing headwear for women with chemotherapy-induced hair loss. *International Journal of Fashion Design, Technology and Education* , 1-11.	Medical	X	Watkins & Dunne (2015)				X	
Gill, S., & Prendergast. (2016). Garment fit and consumer perception of sportswear. In S. G. Hayes & P. Venkatraman (Eds.), *Materials and Technoligies for Sportswear and Performance Apparel* (pp. 245-260). New York: CRC Press.	Sport							
Gon, D. P., & Paul, P. (2011). Complex garment systems to survive in outer space. *Journal of Textile and Apparel, Technology and Management, 7* (2), 1-25.	Review							
Goncu-Berk, G., & Topcuoglu, N. (2017). A healthcare wearable for chronic pain management. Design of a smart glove for rheumatoid arthritis. *The Design Journal, 20* (sup 1), S1978-S1988.	Medical	X	Design of wearables (Goncu-Berk & Topcuoglu, 2017).		X			
Greengrass, J. (2015). From co-design to design specifications and manufacture of apparel for the active ageing population. In J. McCann and D. Bryson (Eds.), *Textile-led design for the active ageing population* (pp. 309-328). Cambridge, UK:Woodbridge Publishing Limited.	Everyday			X				
Gupta, D. (2011a). Design and engineering of functional clothing. *Indian Journal of Fibre & Textile Research, 36* (4), 327-335.	Review							

APPENDIX B.4 – Functional Apparel Literature Review: Production Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Production Dimension				
				Sizing System	Construction	Quality	Ease of Care	Availability
Gupta, D. (2011b). Functional clothing - Definition and classification. *Indian Journal of Fibre & Textile Research, 36* (4), 321-326.	Review			X	X			
Hall, M. L., & Orzada, B. T. (2013). Expressive prostheses: Meaning and significance. *Fashion Practice: The Journal of Design, Creative Process & the Fashion, 5* (1), 9-32.	Review	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)					
Han, F., Shin, K., & Chow, D. (2015). User-centred design approach for hydrotherapy wetsuit. *International Journal of Fashion Design, Technology and Education, 9* (1), 16-22.	Medical	X	User-Centered Design					
Havenith, G., & Heus, R. (2004). A test battery related to ergonomics of protective clothing. *Applied Ergonmics, 35* (1), 3-20.	Occupational			X		X		
Havenith, G., Heus, R., Lotens, W. A., (1990). Resultant clothing insulation: a function of body movement, posture, wind, clothing fit and ensemble thickness. *Ergonomics, 33* (1), 67-84.	Everyday							
Hawkins, M. (1962). Textiles and clothing for older people. *Journal of Home Economics, 54* (10), 852.	Everyday				X		X	
Hayes, M. B., Joiner, L. S., & Caudill, D. C. (1945). Analysis of work shirts and overalls. *Journal of Home Economics, 37* (2), 100-105.	Occupational				X	X	X	
Hendley, A., & Bielby, D. D. (2012). Freedom between the lines: clothing behavior and identity work among young female soccer players. *Sport, Education and Society, 17* (4), 515-533.	Sport	X	Identity theory (Stryker, 1968)					
Ho, C., & Au, Y. (2016). Development of functional racing singlet for professional rowers. *International Journal of Fashion Design, Technology and Education*, 1-9.	Sport	X	Product Design Process (LaBat & Sokolowski, 1999)	X	X			
Ho, S. S., Yu, W. W., Lao, T. T., Chow, D. H., Chung, J. W., & Li, Y. (2009). Garment needs of pregnant women based on content analysis of in-depth interviews. *Journal of Clinical Nursing, 18* (17), 2426-2435.	Everyday							
Holmér, I. (1995). Protective clothing and heat stress. *Ergonomics, 38* (1), 166-182.	Occupational							
Holmér, I. (2006). Protective clothing in hot environments. *Industrial Health, 44* , 404-413.	Occupational							
Hong, Y., Zeng, X., Bruniaux, P., Curteza, A., Stelian, M., & Chen, Y. (2017). Garment opening position evaluation using kinesiological analysis of dressing activities: Case study of physically disabled people with scoliosis (PDPS). *Textile Research Journal, 88* (20), 2303-2318.	Everyday				X			

APPENDIX B.4 – Functional Apparel Literature Review: Production Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Production Dimension				
				Sizing System	Construction	Quality	Ease of Care	Availability
Hooper, D. R., Cook, B. M., Comstock, B. A., Szivak, T. K., Flanagan, S. D., Looney, D. P., . . . Kraemer, W. J. (2015). Synthetic garments enhance comfort, thermoregulatory response, and athletic performance compared with tradional cotton garments. *Journal of Strength and Conditioning Research, 29* (3), 700-707.	Sport							
Huck, J. (1988). Protective clothing systems: A technique for evaluating restriction of wearer mobility. *Applied Ergonomics, 19* , 185-190.	Occupational				X			
Huck, J., & Bonhotal, B. H. (1997). Fastener systems on apparel for hemiplegic stroke victims. *Applied Ergonmics, 28* (4), 277-282.	Medical							
Huck, J., & Kim, Y. (1997). Coveralls for grass fire fighting. *International Journal of Clothing Science and Technology, 9* (5), 346-359.	Occupational	X	DeJonge's (1984) Design process model in *Clothing: The portable environment* by Watkins (1984)	X	X			
Huck, J., Maganga, O., & Kim, J. (1997). Protective overalls: Evaluation of garment design and fit. *International Journal of Clothing Science and Technology, 9* (1), 45-61.	Occupational							
Hwasook, Y. (2013). Consumer perceptions, expectation and satisfaction levels of wear comfrot of hiking gear. *Korean Journal of Human Ecology, 22* (4), 637-650.	Everyday						X	
Hwang, C., Chung, T.-L., & Sanders, E. A. (2016). Attitudes and purchase intentions for smart clothing: Examining U.S. consumers' functional, expressive, and aesthetic needs for solar-powered clothing. *Clothing and Textiles Research Journal, 34* (3), 207-222.	Everyday	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)					
Ilmarinen, R., E., T., & Korhonen, E. (1990). Design of functional work clothing for meat-cutters. *Applied Ergonmics, 21* (1), 2-6.	Occupational						X	
Jankovska D. & Park, J. (2018). A mixed-methods approach to evaluate fit and comfort of the hospital patient gown. *International Journal of Fashion Design, Technology and Education* , 1-10.	Medical			X				
Jin, H., & Black, C. (2012). Assessing functional and aesthetics clothing needs of young male tennis players. *International Journal of Fashion Design, Technology and Education, 5* (2), 145-150.	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X		X		
Johnston, M., & Koo, H. (2016). Apparel design for female rock climbers: satisfactions and preferences. *International Journal of Fashion Design, Technology and Education* , 1-8.	Sport					X	X	
Jung, S., & Chun, J. (2013). Professional climbers' demand for movement functionality in pants. *The Research Journal of the Costume Culture, 21* (2), 261-271.	Sport							

APPENDIX B.4 – Functional Apparel Literature Review: Production Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Production Dimension				
				Sizing System	Construction	Quality	Ease of Care	Availability
Kabel, A., Dimka, J., & McBee-Black, K. (2017). Clothing-related barriers experienced by people with mobility diabilities and impairments. *Applied Ergonmics, 59* , 165-169.	Everyday							X
Kabel, A., McBee-Black, K., & Dimka, J. (2016). Apparel-related participation barriers: Ability, adaptation and engagement. *Disability and Rehabilitation, 38* (22), 2184-2192.	Everyday	X	Universal Design	X				X
Kalayci, E., Ozan Avinc, O., & Yavas, A. (2016). *Textile related extreme sky sports.* Paper presented at the Textile Science and Economy VIII: 8th International Scientific-Professional Conference, Zrenjanin, Serbia.	Sport							
Katsis, C. D., Goletsis, Y., Rigas, G., & Fotiadis, D. I. (2011). A wearable system for the affective monitoring of car racing drivers during simulated conditions. *Transportation Research Part C: Emerging Technologies, 19* (3), 541-551.	Occupational							
Khanna, S., & Kaur, A. (2013). Smart technology in spacesuits. *International Journal of Emerging Research in Management &Technology, 2* (10), 89-93.	Occupational							
Kidd, L. K. (2006). A case study: Creating special occasion garments for young women with special needs. *Clothing and Textiles Research Journal, 24* (2), 161-172.	Everyday				X			
Kim, M. Y. (2013). The development of safety and functional snowboard wear design. *Fashion & Textile Research Journal, 15* (3), 364-370.	Sport							
Kennedy, S. J., (1945). Problems for future Quartermaster textile research. *Textile Research Journal, November* , 413-422.	Review				X			
Klingeberg, T., & Schilling, M. (2012). Mobile wearable device for long term monitoring of vital signs. *Computer Methods and Programs in Biomedicine, 106* (2), 89-96.	Everyday					X		
Koo, S. H. (2018). Understanding consumer preferences on mosquito-bite protective clothing. *International Journal of Clothing Science and Technology, 30* (2), 222-234.	Everyday							
Koo, H. S., & Huang, X. (2015). Visibility aid cycling clothing: flashing light-emitting diode (FLED) configurations. *International Journal of Clothing Science and Technology, 27* (3), 460-471	Sport			X			X	
Koo, H. S., Michaelson, D. M., Teel, K., Kim, D.-H., Park, H., & Park, M. (2016). Design preferences on wearable e-nose systems for diabetes. *International Journal of Clothing Science and Technology, 28* (2), 216-232.	Medical			X			X	

APPENDIX B.4 – Functional Apparel Literature Review: Production Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Production Dimension				
				Sizing System	Construction	Quality	Ease of Care	Availability
Koo, H. S., Teel, K. P., & Han, S. (2016). Explorations of design factors for developments of protective gardening gloves. *Clothing and Textiles Research Journal, 34*(4), 1-15.	Everyday						X	
Kratz, G., Söderback, I., Guidetti, S., Hultling, C., Rykatkin, T., & Söderström, M. (1997) Wheelchair users' experience of non-adapted and adapted clothes during sailing, quad rugby or wheel–walking. *Disability and Rehabilitation, 19*(1), 26-34.	Sport							
Kwok, Y. L., Harlock, S. C., Tam, A. Y. C., & Lo, T. Y. (1997). The design and evaluation of a clothing system for use in the care of premature infants: Part I - The design of the clothing system. *Research Journal of Textiles and Apparel, 1*(1), 99-111.	Medical			X	X			
Kwok, Y. L., Harlock, S. C., Tam, A. Y. C., & Lo, T. Y. (1998). The design and evaluation of a clothing system for use in the care of premature infants: Part II - The evaluation of the clothing system. *Research Journal of Textiles and Apparel, 2*(1), 82-87.	Medical							
Kwok, Y. L., Kong, P. Y., & Fan, J. (1999). Development of swimwear for diving. *Research Journal of Textiles and Apparel, 3*(2), 27-33.	Sport						X	
Kwok, Y. L., Li, H. Y., Fan, J., & Wai, Y. C. (1999). A new design of surgery garments for the patients during operation. *Research Journal of Textiles and Apparel, 3* (2), 53-59.	Medical			X			X	
LaBat, K. L., Ryan, K. S., & Sanden-Will, S. (2016). Breast cancer survivors' wearable product needs and wants: a challenge to designers. *International Journal of Fashion Design, Technology and Education* , 1-12.	Medical			X	X			
Laing, R. M., & Sleivert, G. G. (2002). Clothing, textiles, and human performance. *Textile Progress, 32* (2), 1-122.	Everyday			X				
Lam Po Tang, S. (2015). Wearable sensors for sports performance. In R. Shishoo (Ed.), *Textiles for Sportswear* (pp. 169-196). Cambridge, UK: Woodhead Publishing Limited.	Sport			X	X	X		
Lee, A.-L., Jeong, J.-R., & Kim, H.-E. (2009). Research on the wearing condition of functional mountaineering garments. *Journal of the Korean Society of Clothing and Textiles, 33*(12), 1935-1940.	Sport			X	X	X	X	
Lee, G. R., Graziosi, D., & J., L. (2015, 12-16 July 2015). *The design and development of an extravehicular, stratospheric exploration (stratex) pressure suit.* Paper presented at the 45th International Conference on Environmental Systems, Bellevue, Washington.	Occupational							

APPENDIX B.4 – Functional Apparel Literature Review: Production Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Production Dimension: Sizing System	Construction	Quality	Ease of Care	Availability
Lee, H., Hong, K., & Lee, Y. (2017). Development of 3D patterns for functional outdoor pants based on skin length deformation during movement. *International Journal of Clothing Science and Technology, 29* (2), 148-165.	Everyday				X			
Lee, Y-J., Lee, Y-Y., & Seong, H. W. (2009). A case study on the development of designs for nurses'uniforms. *Journal of the Korean Society of Costume, 59* (10), 22-37.	Occupational							
Leidich, J., Maccagnano, Z., McFatter, D., Lee, G. R., & Hahn, N. (2015). *Stratex pressure suit assembly design and performance.* Paper presented at the International Conference on Environmental Systems, Bellevue, Washington.	Occupational				X			
Linos, E., Keiser, K., Fu, T., Colditz, G., Chen, S., & Yang, J. Y. (2011). Hat, shade, long sleeves, or sunscreen? Rethinking US sun protection messages based on their relative effectiveness. *Cancer Causes & Control, 22* (7), 1067-1071.	Everyday							
Lu, W. (2015). Design for ageing: A focus on China. In J. McCann and D. Bryson (Eds.), *Textile-led design for the active ageing population* (pp. 487-507). Cambridge, UK:Woodbridge Publishing Limited.	Sport			X				
MacDonald, N. M., Bua-Iam, P., & Majumder, R. K. (1994). Clothing purchase decisions and social participation: An empirical investigation of U.S. and U.K. rehabilitation clients. *Journal of Rehabilitation, July-Sept* , 44-50.	Everyday	X	Clothing Purchase Decision-Making Factors (MacDonald, Bua-Lam & Majumber, 1994)			X	X	
Mahoney, D. F., LaRose, S., & Mahoney, E. L. (2015). Family caregivers' perspectives on dementia-related dressing difficulties at home: The preservation of self model. *Dementia, 14* (4), 494-512.	Everyday	X	Various theories on sociology, symbolic use of dress, and dementia					
Makinen, H. (2005). Firefighters' protective clothing. In R. A. Scott (Ed.), *Textiles for protection* (pp. 622-647). Boca Raton, FL: Woodhead Publishing Limited.	Occupational			X			X	
Makinen, H., & Jussila, K. (2014). Cold-protective clothing: types, design and standards. In F. Wang and C. Gao (Eds.), Protective Clothing: Managing Thermal Stress (pp. 2-38). Cambridge, UK: Woodhead Publishing Limited.	Review			X			X	
Malzahn, K., Windmiller, J. R., Valdes-Ramirez, G., Schoning, M. J., & Wang, J. (2011). Wearable electrochemical sensors for in situ analysis in marine environments. *Analyst, 136* (14), 2912-2917.	Sport							
May-Plumlee, T., & Pittman, A. (2002). Surgical gown requirements capture: A design analysis case study. *Journal of Textile and Apparel, Technology and Management, 2* (2), 1-10.	Medical	X	Watkins (1995)	X	X	X		

APPENDIX B.4 – Functional Apparel Literature Review: Production Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Production Dimension				
				Sizing System	Construction	Quality	Ease of Care	Availability
McCann, J. (2015). Environmentally conscious fabric selection in sportswear design. In R. Shishoo (Ed.), *Textiles for Sportswear* (pp. 16-52). Cambridge, UK: Woodhead Publishing Limited	Sport				X			
McCann, J. (2016). Sportswear design for the active ageing. *Fashion Practice: The Journal of Design, Creative Process & the Fashion, 8* (2), 234-256.	Sport			X	X	X		
McCann, J., Hurford, R., & Martin, A. (2005). *A design process for the development of innovative smart clothing that addresses end-user needs from technical, functional, aesthetic and cultural view points.* Paper presented at the Ninth IEEE International Symposium on Wearable Computers (ISWC'05), Osaka, Japan.	Everyday			X	X			
McQuerry, M., Barker, R., & DenHartog, E. (2018). Functional Design and Evaluation of Structural Firefighter Turnout Suits for Improved Thermal Comfort: Thermal Manikin and Physiological Modeling. *Clothing and Textiles Research Journal* , 36(3), 165-179.	Occupational	X	DeJonge's (1984) Design process model in *Clothing: The portable environment* by Watkins (1984)		X			
Michaelson, D., Teel, K., & Chattaraman, V. (2018). Assessing rock climbers' functional needs in climbing pants. *Clothing and Textiles Research Journal, 36* (4), pp. 235-250.	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)					
Michaelson, D., Kim, D-E., & Ha, Y. Scuba Diver's Use of Selection Criteria for Assessing Wetsuit using FEA Model. International Journal of Costume and Fashion, 18(2).	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)					
Mitchka, J., Black, C., Heitmeyer, J., & Cloud, R. M. (2009). Problem structure perceived: Dance practicewear needs of adult female dance students. *Clothing and Textiles Research Journal, 27* (1), 31-44.	Sport	X	DeJonge's (1984) Design process model in *Clothing: The portable environment* by Watkins (1984)	X	X	X		
Morris, K., Park, J., & Sarkar, A. (2017). Development of a nursing sports bra for physically active breastfeeding women through user-centered design. *Clothing and Textiles Research Journal, 35* (4), 290-306.	Sport	X	User-Centered Design	X	X			X
Morrissey, M. P., & Rossi, R. M. (2013). Clothing systems for outdoor activities. *Textile Progress, 45* (2-3), 145-181.	Sport							
Motlogelwa, S. (2018). Comfort and durability in high-performance clothing. In J. McLoughlin & T. Sabir (Eds.), *High-Performance Apparel* (1st ed., pp. 209-219). Cambridge, UK: Woodhead Publishing.	Occupational			X	X			
Na, H.-S. (2007). Adaptive clothing designs for the individuals with special needs. *Journal of the Korean Society of Clothing and Textiles, 31* (6), 933-941.	Everyday				X			

APPENDIX B.4 – Functional Apparel Literature Review: Production Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Production Dimension				
				Sizing System	Construction	Quality	Ease of Care	Availability
Naesgaard, O. P., Storholmen, T. C. B., Wiggen, Ø. N., & Reitan, J. (2017). A user-centred design process of new cold-protective clothing for offshore petroleum workers operating in the Barents Sea. *Industrial Health, 55* (6), 564-574.	Occupational	X	User-Centered Design					
Nasir, S. H., Troynikov, O. & Massy-Westropp, N. (2017). Arthritis patients' experience and perception of therapeutic gloves. *International Journal of Fashion Design, Technology and Education, 11* (2), 233-242.	Medical							
Nayak, R., Houshyar, S., & Padhye, R. (2014) Recent trends and fiture scope in the protection and comfort of firefighters' personal protective clothing. *Fire Science Reviews, 3* (4), 1-19.	Review			X	X		X	
Newton, A. (1976). Clothing: A positive part of the rehabilitation process. *Journal of Rehabilitation, 42* (5), 18-22.	Everyday							
Park, H., & Hahn, K. H. Y. (2014). Perception of firefighters' turnout ensemble and level of satisfaction by body movement. *International Journal of Fashion Design, Technology and Education, 7* (2), 85-95.	Occupational							X
Park, H., Nolli, G., Branson, D., Peksoz, S., Petrova, A., & Goad, C. (2011). Impact of wearing body armor on lower body mobility. *Clothing and Textiles Research Journal, 29* (3), 232-247.	Occupational							
Park, H., Park, J., Lin, S.-H., & Boorady, L. M. (2014). Assessment of firefighters needs for personal protective equipment. *Fashion and Textiles, 1* (8), 1-13.	Occupational			X				
Park, J. (2014). Development of an integrative process model for universal design and an empirical evaluation with hospital patient apparel. *International Journal of Fashion Design, Technology and Education, 7* (3), 179-188.	Medical	X	Universal design & Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)			X		
Parker, R., Vitalis, A., Walker, R., Riley, D., & Pearce, H. G. (2017). Measuring wildland fire fighter performance with wearable technology. *Appled Ergonomics, 59* (Pt A), 34-44.	Occupational							
Perkins, H. M., Crown, E. M., Rigakis, K. B., & Eggertson, B. S. (1992). Attitudes and behavioral intentions of agricultural workers toward disposable protective coveralls. *Clothing and Textiles Research Journal, 11* (1), 67-73.	Occupational	X	Fishbein-Ajzen (1980) Theory of Reasoned Action				X	
Perry, A., & Lee, J. (2017). Satisfaction with current martial arts' uniforms and purchase intention of new uniforms. *Fashion and Textiles, 4* (1).	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X		X	X	X

APPENDIX B.4 – Functional Apparel Literature Review: Production Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Production Dimension				
				Sizing System	Construction	Quality	Ease of Care	Availability
Perry, A., Malinin, L., Sanders, E., Li, Y., & Leigh, K. (2017). Explore consumer needs and design purposes of smart clothing from designers' perspectives. *International Journal of Fashion Design, Technology and Education, 10* (3), 1-9.	Everyday					X	X	
Pompelli, J. (1998). *Dressing for independence: Adapting clothing for kids with special needs* (Vol. 1). Chesterfield, MO: Wings Way Press.	Everyday							
Power, E. J., Leaper, D. J., & Harris, J. M. (2017). Designing functional medical products for children with cancer. *International Journal of Fashion Design, Technology and Education, 10* (3), 1-6.	Medical	X	Quality Function Deployment					
Rantanen, J., Alfthan, N., Impio, J., Karinsalo, T., Malmivaara, M., Matala, R., . . . Tasanen, M. (Oct. 10-13, 2010). *Smart clothing for the arctic environment* . Paper presented at the Wearable Computers, The Fourth International Symposium, COEX, Seoul, South Korea.	Everyday						X	
Reddy-Best, K. L., & Harmon, J. (2015). Overweight boy's and girl's experiences with and perception of athletic clothing and its relationship to physical activity participation. *Fashion and Textiles, 2* (23), 1-16.	Sport			X				
Rosenblad-William, E. (1985). User-oriented production development applied to functional clothing design. *Applied Ergonmics, 16* (4), 279-287.	Everyday			X				
Rossi, R. (2014). Clothing for protection against heat and flames. In F. Wang and C. Gao (Eds.), *Protective Clothing: Managing Thermal Stress* (pp. 70-89). Cambridge, UK: Woodhead Publishing Limited.	Occupational							
Rossi, R. M. (2015). Cold weather sports clothing. In R. Shishoo (Ed.), *Textiles for Sportswear* (pp. 197-212). Cambridge, UK: Woodhead Publishing Limited.	Review							
Rucker, M., Anderson, E., & Kangas, A. (2000). Evaluation of standard and prototype protective garments for wildland firefighters. In C. Nelson and N. Henry III (Ed.), *Performance of protective clothing: Issues and priorities for the 21st century* (Vol. 7, pp. 546-556). West Conshohocken, PA: American Society for Testing and Materials.	Occupational			X			X	
Ruckman, J. E., Murray, R., & Choi, H. S. (1999). Engineering of clothing systems for improved thermophysiological comfort: The effect of openings. *International Journal of Clothing Science and Technology, 11* (1), 37-52.	Everyday							
Rusk, H. A., & Taylor, E. J. (1959). Functional fashions for the physically handicapped. *Journal of the American Medical Association, 169* (14), 1598-1600.	Everyday			X	X		X	

APPENDIX B.4 – Functional Apparel Literature Review: Production Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Production Dimension				
				Sizing System	Construction	Quality	Ease of Care	Availability
Rutherford-Black, C., & Khan, S. (1995). Texas tech police bicycle patrol: Encounter with a uniform. *Campus Law Enforcement Journal, 25*(6), 26-28.	Occupational					X	X	
Sarkar, A. K. (2005). Textiles for UV protection. In R. A. Scott (Ed.), *Textiles for protection* (pp. 355-377). Boca Raton, FL: Woodhead Publishing Limited.	Everyday				X		X	
Sau-Fun, N., Chi-Leung, H., & Lai-Fan, W. (2011). Development of medical garments and apparel for the elderly and the disabled. *Textile Progress, 43*(4), 235-285.	Medical					X	X	
Schulte, B. F. (2015). Designing garments for people with dementia: Innovative practice. *Dementia,14*(5), 691-695.	Everyday							
Schuste, J. D., & Kelly, D. H. (1974). Preferred style features in dresses for physically handicapped elderly women. *The Gerontologist, 14*(2), 106-109.	Everyday							
Scott, R. A. (2005). Military Protection. In R. A. Scott (Ed.), *Textiles for protection* (pp. 597-621). Boca Raton, FL: Woodhead Publishing Limited.	Occupational							
Shanley, L. A., Slaten, B. L., & Shanley, P. S. (1993). Military protective clothing: Implications for clothing and textiles curriculum and research. *Clothing and Textiles Research Journal, 11*(3), 55-59.	Occupational							
Shin, S., Smith, B., & Gaines, K. (2015). *Investigation of Therapy Clothing Products for Children with Autism Spectrum Disorders*. Paper presented at the International Textile and Apparel Association (ITAA) Annual Conference Proceedings, Santa Fe, New Mexico.	Everyday			X				
Song, R., & Stone, J. F. (2005). Shirt desings for sun protection. *Journal of Environmental Health, 67*(10), 50-56.	Everyday						X	
Sontag, M. S. (1986). Comfort dimensions of actual and ideal insulative clothing for older women. *Clothing and Textiles Research Journal, 4*(1), 9-17.	Everyday	X	Comfort Dimensions (Sontag, 1986)					
Sperling, L., & Karlsson, M. (1989). Clothing fasteners for long-term-care patients. *Applied Ergonmics, 20*(2), 97-104.	Medical				X		X	
Spitz, M. G., Johnson, W. K., Lesher, L. L., & Arcidiacono, S. (2016). Soldier hygiene issues and use of antimicrobial textiles in the military. *AATCC Journal of Research, 3*(5), 27-37.	Occupational						X	
Stokes, B., & Black, C. (2012). Application of the functional, expressive and aesthetic consumer needs model: Assessing the clothing needs of adolescent girls with disabilities. *International Journal of Fashion Design, Technology and Education, 5*(3), 179-186.	Everyday	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)					

APPENDIX B.4 – Functional Apparel Literature Review: Production Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Production Dimension				
				Sizing System	Construction	Quality	Ease of Care	Availability
Stull, J. O. (2005). Civilian protection and protection of industrial workers from chemicals. In R. A. Scott (Ed.), *Textiles for protection* (pp. 296-354). Boca Raton, FL: Woodhead Publishing Limited.	Occupational			X	X		X	
Sweeney, D. H., & Taber, M. J. (2014). Cold-water immersion suits. In F. Wang and C. Gao (Eds.), *Protective Clothing: Managing Thermal Stress* (pp. 39-69). Cambridge, UK: Woodhead Publishing Limited.	Occupational			X	X		X	
Suh, C. (2013). A survery on the purchasing behavior and preference of mountain climbing pants for the development of women's functional ,ountain climbing pants patterns. *Journal of the Korean Society of Clothing and Textiles, 37* (1), 90-100.	Sport							
Tamura, T. (2016). Climate and clothing. *Journal of the Human-Environment System, 19* (1), 1-11.	Everyday							
Tan, Y., Crown, E. M., & Capjack, L. (1998). Design and evaluation of thermal protective flightsuits. Part I: The design process and prototype development. *Clothing and Textiles Research Journal, 16* (1), 47-55.	Occupational	X	Objectifying apparel design process (Orlando, 1979)	X	X	X	X	
Teunissen, L. P., Wang, L.-C., Chou, S.-N., Huang, C.-h., Jou, G.-T., & Daanen, H. A. (2014). Evaluation of two cooling systems under a firefighter coverall. *Applied Ergonomics, 45* (6), 1433-1438.	Occupational							
Thompson, D. (2017). Design criteria utilised to develop prototype jackets for motorcycle riders in rural communities of Akwa Ibom State, Nigeria. *Journal of Emerging Trends in Economics and Management Sciences, 8* (3), 178-182.	Everyday			X			X	X
Thompson, D., & Anyakoha, E. (2012). Assessment of expressive attributes of functional apparel product developed for cosmetologists in Lagos, Nigeria. *International Journal of Consumer Studies, 36* (4), 492-497.	Occupational	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)					
Thoren, M. (1996). Systems approach to clothing for disabled users: Why is it difficult for disabled users to find suitable clothing? *Appled Ergonomics, 27* (6), 389-396.	Everyday	X	User-Oriented Product Development (Rosenblad, 1983; Dahlman, 1986) & Soft systems methodology (Checkland, 1991)					
Tremblay-Lutter, J. F., Crown, E. M., & Rigakis, K. B. (1996). Evaluation of functional fit of chemical protective gloves for agricultural workers. *Clothing and Textiles Research Journal, 14* (3), 216-224.	Occupational	X	Engineering anthropometry methods (Roebuck, 1975)	X				
Truong, Q., & Wilusz, W. (2005). Chemical and biological protection. In R. A. Scott (Ed.), *Textiles for protection* (pp. 557-596). Boca Raton, FL: Woodhead Publishing Limited.	Occupational				X		X	

APPENDIX B.4 – Functional Apparel Literature Review: Production Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Production Dimension				
				Sizing System	Construction	Quality	Ease of Care	Availability
Tullio-Pow, S., Schaefer, K., Zhu, R., Kolenchenko, O., & Nyhof-Young, J. (April 18-20 2011). *Sweet dreams: Needs assessment and prototype design of post-mastectomy sleepwear.* Paper presented at the The Role of Inclusive Design in Making Social Innovation Happen, London.	Everyday	X	User-Oriented Product Development (Rosenblad, 1983) & Universal Design (Story, 2001)	X				X
Tuteja, S., & Nigam, V. (2018). Functional clothing for individuals with special needs. *International Journal of Research, 4*(7), 963-967.	Everyday				X			
Van Wely, E. (2017). Current global standards for chemical protective clothing: How to choose the right protection for the right job? *Industrial Health, 55*, 485-499.	Review				X	X	X	
Varnsverry, P. (2005). Motorcyclists. In R. A. Scott (Ed.), *Textiles for protection* (pp. 714-733). Boca Raton, FL: Woodhead Publishing Limited.	Everyday				X	X		
Warden, J., & Dedmon, K., (1975). Clothing design uses style and utility. *Journal of Rehabilitation, July/August*, 17-24.	Everyday			X				
Wang, Y., Wu, D., Zhao, M., & Li, J. (2014). Evaluation on an ergonomic design of functional clothing for wheelchair users. *Applied Ergonomics, 45*(3), 550-555.	Everyday	X	User-Oriented Product Development (Rosenblad, 1983)					
Webster, J., & Roberts, J. (2011). Determining the effect of cricket leg guards on running performance. *Journal of Sports Sciences, 29*(7), 749-760.	Sport							
Wheat, K. L., & Dickson, M. A. (1999). Uniforms for collegiate female golfers: Cause for dissatisfaction and role conflict? *Clothing and Textiles Research Journal, 17*(1), 1-10.	Sport				X	X	X	
Wong, W. K., Kwok, Y. L., Chan, K., & Yeung, C. Y. (1999). An investigation of physical functional design on child patients' garment. *Research Journal of Textiles and Apparel, 3*(2), 34-40.	Medical			X			X	
Worland, M., Black, C. & Freeman, C. (2017). Pre-purchase and post-purchase apparel satisfaction of female skiers and snowboarders. *International Journal of Fashion Design, Technology and Education, 10*(2), 200-208.	Sport	X	Functional, Expressive, and Aesthetic design framework by Lamb & Kallal (1992)	X	X	X	X	
Yick, K. L., Lai, K. Y., Tsui, H. M., & Kwan, S. Y. (2012). Effects of design attributes on the functional performance of restraint garments for hospital patients. *Research Journal of Textiles and Apparel, 16*(4), 29-41.	Medical				X			
Zhang, L., & Zhao, Y. (2013). The status analysis of volleyball apparel structure design. Advanced Materials Research, 821-822, 781-785.	Sport							

APPENDIX B.4 – Functional Apparel Literature Review: Production Dimension

Source	End User Apparel Type	Framework Used	Name of Framework	Production Dimension				
				Sizing System	Construction	Quality	Ease of Care	Availability
Zhen Wang, W., Wang, Y., Lian Yu, S., Sun, L., Liu, J., & Min Wei, X. (2014). Design for mutual transformation between outdoor wear and camping tent. *International Journal of Clothing Science and Technology, 26* (4), 291-304	Everyday				X			
		50		56	60	30	50	12

APPENDIX C – Case study 1 Questionnaire

USA Verify

This study is investigating usage of sun protective apparel in children. Please indicate if you are a parent, family member, or caregiver of a child (under 18) and currently reside in the United States.

- Yes
- No

Consent

APPENDIX C – Case study 1 Questionnaire

DEPARTMENT OF CONSUMER AND DESIGN SCIENCES

AUBURN UNIVERSITY

COLLEGE OF HUMAN SCIENCES

(NOTE: DO NOT AGREE TO PARTICIPATE UNLESS AN IRB APPROVAL STAMP WITH CURRENT DATES HAS BEEN APPLIED TO THIS DOCUMENT.)

INFORMATION LETTER
for a Research Study entitled
"Investigating Usage and Effectiveness of Sun Protective Apparel in Children"

You are invited to participate in a research study that investigates the expectations of children sun protection apparel, the prevalence of sun-protective clothing usage in children, the types of sun protection currently being used on children, the perceived deterrents for using of sun protective clothing, and how a parents' role moderates attitude, perception of subjective norms, and perceived behavioral control of using sun protective apparel on their child which may ensure a child's intention to use sun protective apparel in the future. The study is being conducted by Dawn Michaelson, doctoral student, under the direction of Karla P. Teel, PhD. in the Auburn University Department of Consumer and Design Sciences. You are invited to participate because you are parent or caregiver of a child and are age 19 or older.

What will be involved if you participate? If you decide to participate in this research study, you will be asked to *complete a questionnaire about your child's usage of sun protection, time spend in water, and perceptions of sun protection.* Your total time commitment will be approximately 15 minutes.

Are there any risks or discomforts? There are no known risks associated with participating in this study.

Are there any benefits to yourself or others? If you participate in this study, you can expect to help our understanding of children sun protection usage and perceived deterrent of using children sun protective apparel. We cannot promise you that you will receive any or all the benefits described.

Will you receive compensation for participating? There will be no compensation from Auburn University or the researchers of this study.

Are there any costs? There are no costs if you decide to participate or if you withdraw from the study.

If you change your mind about participating, you can withdraw at any time during the study. Your participation is completely voluntary. If you choose to withdraw, your data can be withdrawn if it is identifiable. Your decision about whether to participate or to stop participating will not jeopardize your future relations with Auburn University, the Department of Consumer & Design Sciences.

Any data obtained in connection with this study will remain anonymous. We will protect your privacy and the data you provide by destroying it two years after completion of the study. Information collected through your participation may be used to fulfill an educational requirement, published in a professional journal, and/or presented at a professional meeting.

If you have questions about this study, contact Dawn Michaelson at dmm0029@auburn.edu or Karla P. Teel, PhD. at 334-844-1345.

If you have questions about your rights as a research participant, you may contact the Auburn University Office of Research Compliance or the Institutional Review Board by phone (334)-844-5966 or e-mail at IRBadmin@auburn.edu or IRBChair@auburn.edu.

HAVING READ THE INFORMATION PROVIDED, YOU MUST DECIDE IF YOU WANT TO PARTICIPATE IN THIS RESEARCH PROJECT. IF YOU DECIDE TO PARTICIPATE, THE DATA YOU PROVIDE WILL SERVE AS YOUR AGREEMENT TO DO SO. THIS LETTER IS YOURS TO KEEP.

Dawn Michaelson 10/3/18

Dawn Michaelson Date

308 Spidle Hall, Auburn, AL 36849-5601; Telephone: 334-844-4084; Fax: 334-844-1340

www.auburn.edu

Sun Habits

This child is a

- ○ Boy
- ○ Girl
- ○ Prefer to not state

This summer, on average, how many hours per day is this child outside swimming or playing in the water between 10 am and 4 pm on WEEKDAYS (Please round to the nearest hour, and enter a whole number 0-12):

APPENDIX C – Case study 1 Questionnaire

This summer, on average, how many hours per day is this child outside swimming or playing in the water between 10 am and 4 pm on WEEKENDS (Please round to the nearest hour, and enter a whole number 0-12):

[ ]

In the past 12 months, how many times did this child have a red, non-blistered sunburn:

[ ]

What skin type is this child?

- ○ Sunburn easily and are not likely to tan.
- ○ Usually sunburn easily and tan a little.
- ○ Sunburn sometimes and tan slowly.
- ○ Sunburn a little and usually tan well.
- ○ Rarely sunburn, and tan deeply.
- ○ Almost never sunburn.

Types used

What types of sun protection does this child wear in the water while outside? List all of them below.

- ☐ Sunscreen
- ☐ Sun glasses
- ☐ Wide brimmed hat
- ☐ Short sleeve shirt
- ☐ Long sleeve shirt
- ☐ Pants
- ☐ Shorts
- ☐ Skirt

Role

For the following questions, think about the child outside swimming or playing in the water during the summer on a warm sunny day. Indicate the number that represents how you feel about the

APPENDIX C – Case study 1 Questionnaire

following questions.

I believe it is my responsibility as a parent, family member, or caregiver to ensure that this child wears sun protection.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

I make sure that this child wears sun protection.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

I believe it is my responsibility as a parent, family member, or caregiver to ensure this child understands why it is important to wear sun protection.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

APPENDIX C – Case study 1 Questionnaire

I'm committed to being a good parent, family member, or caregiver?

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

Recent research on decision making shows that choices are affected by context. Specifically, we are interested in whether you actually take the time to read each question. To show that you are paying attention, please check only the "none of the above" option as your answer.

- Interested
- Distressed
- Excited
- Upset
- Strong
- Guilty
- Scared
- Hostile
- Enthusiastic
- None of the above

The people in my life whose opinions I value would approve of me ensuring that this child wears sun protective.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

APPENDIX C – Case study 1 Questionnaire

Most people who are important to me think I should ensure this child is wearing sun protective apparel.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

I've noticed that more and more children are wearing sun protective apparel.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

It seems like more parents, family members, or caregivers are protecting children from the sun by having them wearing sun protective apparel.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

Ensuring this child wears sun protection apparel takes too much time.

- Strongly disagree

- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

Ensuring this child wears sun protection apparel costs too much money.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

Ensuring this child wears sun protection apparel requires strong motivation.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

Other types of sun protection are more convenient.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree

- Strongly agree

I don't always know which types of sun protection are best.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

Other types of sun protection are more available than sun protective apparel.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

I intend to ensure this child wears sun protective apparel.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

I plan to ensure this child wears sun protective apparel.

- Strongly disagree

APPENDIX C – Case study 1 Questionnaire

- ○ Disagree
- ○ Somewhat disagree
- ○ Neither agree nor disagree
- ○ Somewhat agree
- ○ Agree
- ○ Strongly agree

I want to ensure this child wears sun protective apparel.

- ○ Strongly disagree
- ○ Disagree
- ○ Somewhat disagree
- ○ Neither agree nor disagree
- ○ Somewhat agree
- ○ Agree
- ○ Strongly agree

This child wearing sun protective apparel is:

Bad	○	○	○	○	○	○	○ Good
Unfavorable	○	○	○	○	○	○	○ Favorable
Harmful	○	○	○	○	○	○	○ Beneficial
Foolish	○	○	○	○	○	○	○ Wise
Unnecessary	○	○	○	○	○	○	○ Necessary

Ownership

Does this child own (or has ever owned) sun protective apparel?

- ○ Yes
- ○ No

APPENDIX C – Case study 1 Questionnaire

What are the reasons for not using or purchasing children's sun protective apparel? List all the reasons below.

Variables

Answer the following questions based on your current (or past) experience with this child's sun protective apparel.

This child's sun protective apparel is comfortable.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

This child is able to move properly in sun protective apparel.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

This child's sun protective apparel is good for this child's body shape.

- Strongly disagree

- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

The sizing of sun protective apparel is accurate.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

I feel the sun protective apparel protected this child from sun.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

This child's sun protective apparel is durable.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree

- Strongly agree

This child or myself can easily put on sun protective apparel.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

This child or myself can easily remove their sun protective apparel.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

Fit Satisfaction

Indicate your fit satisfaction with this child's sun protective apparel for each of the following body areas:

	Extremely dissatisfied	Moderately dissatisfied	Slightly dissatisfied	Neither satisfied nor dissatisfied	Slightly satisfied	Moderately satisfied	Extremely satisfied	Not applicable
Neckline	O	O	O	O	O	O	O	O
Sleeve Length	O	O	O	O	O	O	O	O
Waist Length	O	O	O	O	O	O	O	O
Waist	O	O	O	O	O	O	O	O

APPENDIX C – Case study 1 Questionnaire

	Extremely dissatisfied	Moderately dissatisfied	Slightly dissatisfied	Neither satisfied nor dissatisfied	Slightly satisfied	Moderately satisfied	Extremely satisfied	Not applicable
Abdomen	O	O	O	O	O	O	O	O
Shoulder	O	O	O	O	O	O	O	O
Armhole	O	O	O	O	O	O	O	O
Upper Arm	O	O	O	O	O	O	O	O
Lower Arm	O	O	O	O	O	O	O	O
Elbow	O	O	O	O	O	O	O	O
Pant Length	O	O	O	O	O	O	O	O
Short Length	O	O	O	O	O	O	O	O
Shirt Length	O	O	O	O	O	O	O	O
Crotch	O	O	O	O	O	O	O	O
Thigh	O	O	O	O	O	O	O	O
Buttocks	O	O	O	O	O	O	O	O

Variables2

I am satisfied with the fabrics and fasteners of this child's sun protective apparel.

- O Strongly disagree
- O Disagree
- O Somewhat disagree
- O Neither agree nor disagree
- O Somewhat agree
- O Agree
- O Strongly agree

I am satisfied with the construction of this child's sun protective apparel.

- O Strongly disagree
- O Disagree
- O Somewhat disagree

- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

I am satisfied with the quality of this child's sun protective apparel.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

I am satisfied with the ease of care of this child's sun protective apparel.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

I feel sun protective apparel is affordable.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

APPENDIX C – Case study 1 Questionnaire

I am satisfied with the availability of sun protective apparel in stores.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

What styles of sun protective apparel does this child prefer to wear in the water. List below.

Are there any other reasons why sun protective apparel does not fully satisfy you or this child's needs? List all the reasons below.

Purchase Intentions

I intend to purchase sun protection apparel.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

I wish to purchase sun protection apparel if I can afford it.

APPENDIX C – Case study 1 Questionnaire

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

I have the desire to use sun protection apparel.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

I feel positive about purchasing sun protective apparel.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree
- Agree
- Strongly agree

I would recommend sun protective apparel to my neighbors.

- Strongly disagree
- Disagree
- Somewhat disagree
- Neither agree nor disagree
- Somewhat agree

- Agree
- Strongly agree

CDC

Did you know the Centers for Disease Control and Prevention (CDC) and The Skin Cancer Foundation states the best sun protection is ultraviolet (UV) clothing?

- Yes
- No

Does this knowledge change your feelings about sun protective apparel?

- Yes
- No

Explain below.

Demographics

We would like to know some information about you and the child.

Child's Age (Please round to the nearest year, and enter a whole number.)

Your Age (Please round to the nearest year, and enter a whole number.)

What is your gender?

APPENDIX C – Case study 1 Questionnaire

- Male
- Female
- Prefer not to state

What is your relationship to the child?

- Parent
- Family Member
- Caregiver
- Other

In which state do you currently reside?

Indicate your ethnicity?

- Caucasian
- African-American
- Hispanic
- Asian
- American Indian/Alaskan Native
- Other (please describe)

What is educational level?

- High School / GED
- Bachelor's
- Masters
- Doctoral
- Other (please describe)

What is your marital status?

- Married
- Widowed
- Divorced
- Separated
- Never married

APPENDIX C – Case study 1 Questionnaire

If there is any additional information you would like to share please provide it below.

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APPENDIX D – Case study 2 Questionnaire

AUBURN
UNIVERSITY

Introduction

DEPARTMENT OF
CONSUMER AFFAIRS

AUBURN UNIVERSITY
COLLEGE OF HUMAN SCIENCES

Dear Wildland Firefighter,

We realize it has been a very active and hard fire season for wildland firefighters' and we appreciate you taking the time to help us with our research. At this time we would like to invite you to participate in our research study investigating wildland firefighters' perceptions of their NFPA 1977 Protective Clothing. You may participate if you are a wildland firefighter, age 19 or older, and have worn NFPA 1977 protective apparel in the past 12 months. Your total time commitment will be approximately 15 minutes. To thank you for your time you will be offered a chance to win a $50 Amazon e-gift card.

If you would like to participate and meet the requirements please click the forward button to start the questionnaire.

APPENDIX D – Case study 2 Questionnaire

The Auburn University Institutional Review Board has approved this Document for use from 06/21/2018 to ---
Protocol # 18-261 EX 1806

DEPARTMENT OF CONSUMER AND DESIGN SCIENCES

AUBURN UNIVERSITY

COLLEGE OF HUMAN SCIENCES

(NOTE: DO NOT AGREE TO PARTICIPATE UNLESS AN IRB APPROVAL STAMP WITH CURRENT DATES HAS BEEN APPLIED TO THIS DOCUMENT.)

INFORMATION LETTER
for a Research Study entitled
"Wildland Firefighters' Perceptions of NFPA 1977 Protective Apparel"

You are invited to participate in a research study that is investigating wildland firefighters' perceptions of their NFPA 1977 Protective Clothing based on regulations, equipment interactions, fit, body shape, mobility, comfort, donning and doffing ease, protection, performance, design details, fasteners/closures, construction, quality, ease of care, durability, sizing, availability, and affordability. The study is being conducted by Dawn Michaelson, doctoral student, under the direction of Karla P. Teel, PhD. in the Auburn University Department of Consumer and Design Sciences. You are invited to participate because you are a wildland firefighter, age 19 or older, and have worn NFPA 1977 protective apparel in the past 12 months.

What will be involved if you participate? If you decide to participate in this research study, you will be asked to complete an online questionnaire about your perceptions of your NFPA 1977 Protective Clothing. Your total time commitment will be approximately 15 minutes.

Are there any risks or discomforts? There are no known risks associated with participating in this study.

Are there any benefits to yourself or others? If you participate in this study, you can expect to help the firefighting industry knowledge of wildland firefighters' perceptions of NFPA 1977 Protective Clothing. We cannot promise you that you will receive any or all of the benefits described.

Will you receive compensation for participating? To thank you for your time you will be offered a chance to win a $50 Amazon e-gift card. Chances of winning are 1 in 50.

Are there any costs? There are no costs if you decide to participate.

If you change your mind about participating, you can withdraw at any time during the study. Your participation is completely voluntary. If you choose to withdraw, your data can be withdrawn as long as it is identifiable. Your decision about whether or not to participate or to stop participating will not jeopardize your future relations with Auburn University, the Department of Consumer & Design Sciences.

Any data obtained in connection with this study will remain anonymous. We will protect your privacy and the data you provide by not collecting any computer or personal information. All questionnaire response data will be destroyed two years after completion of the study. Information collected through your participation may be used to fulfill an educational requirement, published in a professional journal, and/or presented at a professional meeting.

If you have questions about this study, *please ask them now or* contact Dawn Michaelson at dmm0029@auburn.edu or Karla P. Teel, PhD. at 334-844-1345.

If you have questions about your rights as a research participant, you may contact the Auburn University Office of Research Compliance or the Institutional Review Board by phone (334)-844-5966 or e-mail at IRBadmin@auburn.edu or IRBChair@auburn.edu.

HAVING READ THE INFORMATION PROVIDED, YOU MUST DECIDE IF YOU WANT TO PARTICIPATE IN THIS RESEARCH PROJECT. IF YOU DECIDE TO PARTICIPATE, THE DATA YOU PROVIDE WILL SERVE AS YOUR AGREEMENT TO DO SO. THIS LETTER IS YOURS TO KEEP.

Dawn Michaelson 6/18/18

Dawn Michaelson Date

308 Spidle Hall, Auburn, AL 36849-5601; Telephone: 334-844-4084; Fax: 334-844-1340
www.auburn.edu

APPENDIX D – Case study 2 Questionnaire

Regulation

Does your wildland firefighter protective apparel meet NFPA 1977 regulations?

- ○ Yes
- ○ No
- ○ I do not know

Have you found that you prefer a particular edition of NFPA 1977 wildland firefighting protective apparel? Check all that apply.

- ☐ edition 2005 shirt
- ☐ edition 2005 pant
- ☐ edition 2011 shirt
- ☐ edition 2011 pant
- ☐ edition 2016 shirt
- ☐ edition 2016 pant
- ☐ I do not have a preference

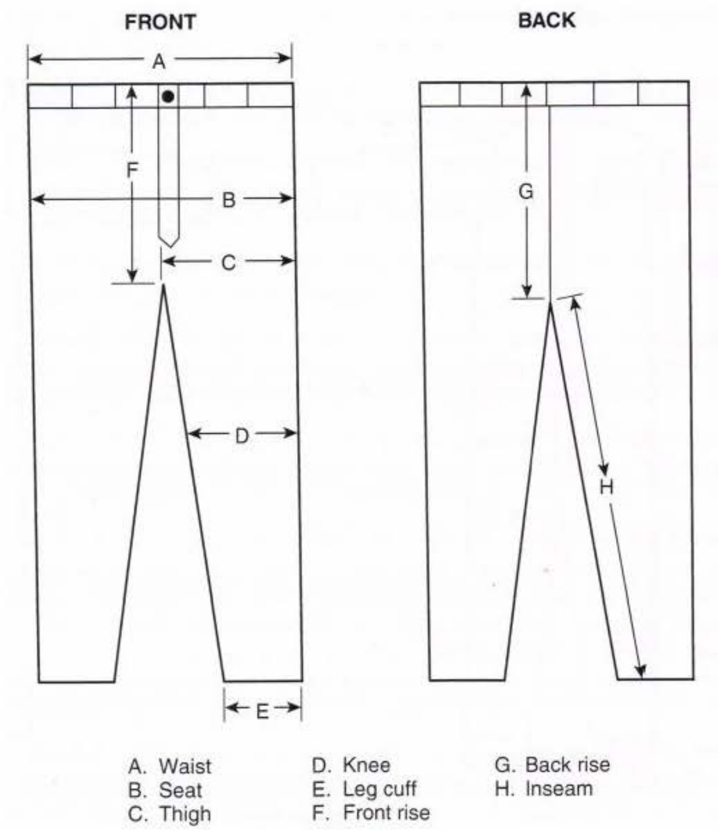
Pant

For the following questions, think about your wildland firefighting pants you typically wear while working.

What size do you prefer to wear for your firefighting pants?

APPENDIX D – Case study 2 Questionnaire

Indicate your pant fit satisfaction for each of the following areas:



	Extremely satisfied	Moderately satisfied	Slightly satisfied	Neutral	Slightly dissatisfied	Moderately dissatisfied	Extremely dissatisfied	Not applicable
A. Waist	O	O	O	O	O	O	O	O
B. Seat	O	O	O	O	O	O	O	O
C. Thigh	O	O	O	O	O	O	O	O
D. Knee	O	O	O	O	O	O	O	O
E. Leg Cuff	O	O	O	O	O	O	O	O
F. Front Rise	O	O	O	O	O	O	O	O
G. Back Rise	O	O	O	O	O	O	O	O
H. Inseam	O	O	O	O	O	O	O	O

If you could change the fit of the pant, what would you change? Explain below. (If no changes you can skip the question.)

APPENDIX D – Case study 2 Questionnaire

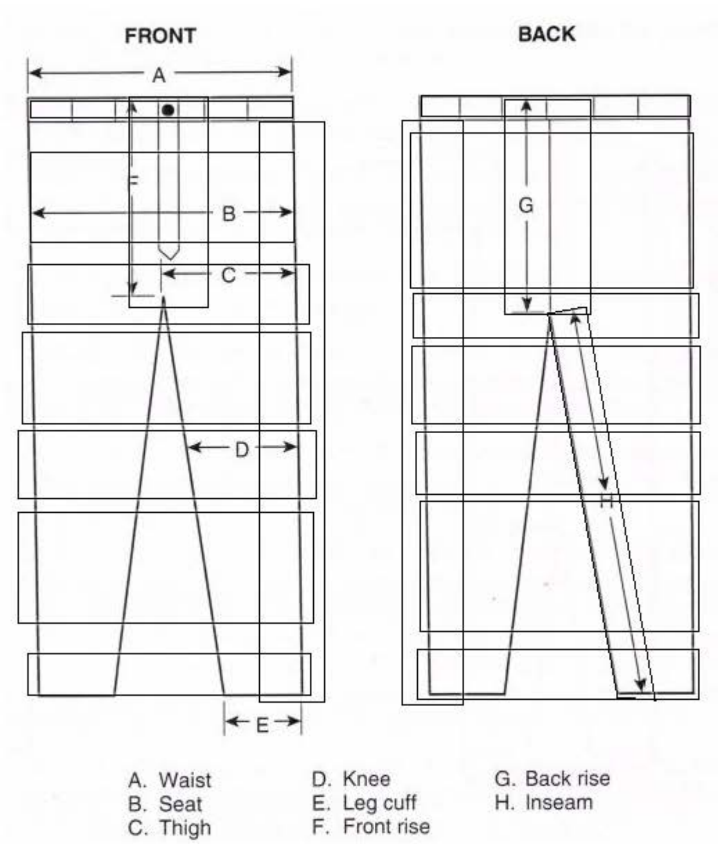
Is there a brand or manufacturer of wildland firefighting pants that you prefer to wear? Explain why you prefer that brand/manufacturer over others.

Select a location between the pair of adjectives at the location that best describes how you feel about your wildland firefighting pant.

Comfortable	O	O	O	O	O	O	O	Uncomfortable
Acceptable	O	O	O	O	O	O	O	Unacceptable
Flexible	O	O	O	O	O	O	O	Stiff
Easy to put on	O	O	O	O	O	O	O	Hard to put on
Freedom of movement in legs	O	O	O	O	O	O	O	Restrict movement in legs
Like	O	O	O	O	O	O	O	Dislike
Loose	O	O	O	O	O	O	O	Tight
Sturdy	O	O	O	O	O	O	O	Not sturdy
Cold	O	O	O	O	O	O	O	Hot
Soft to the skin	O	O	O	O	O	O	O	Harsh to the skin
Machine washable	O	O	O	O	O	O	O	Not machine washable
Easy care	O	O	O	O	O	O	O	Not easy care
Durable	O	O	O	O	O	O	O	Not durable
High quality	O	O	O	O	O	O	O	Low quality
Breathable	O	O	O	O	O	O	O	Does not breath
Easy to remove	O	O	O	O	O	O	O	Hard to remove
Functional	O	O	O	O	O	O	O	Not functional
Lightweight	O	O	O	O	O	O	O	Heavyweight
Non-irritating	O	O	O	O	O	O	O	Irritating
Low Static	O	O	O	O	O	O	O	High Static

Select the areas which cause you problems with mobility while working. Click all that apply. (If no problems you can skip the question.)

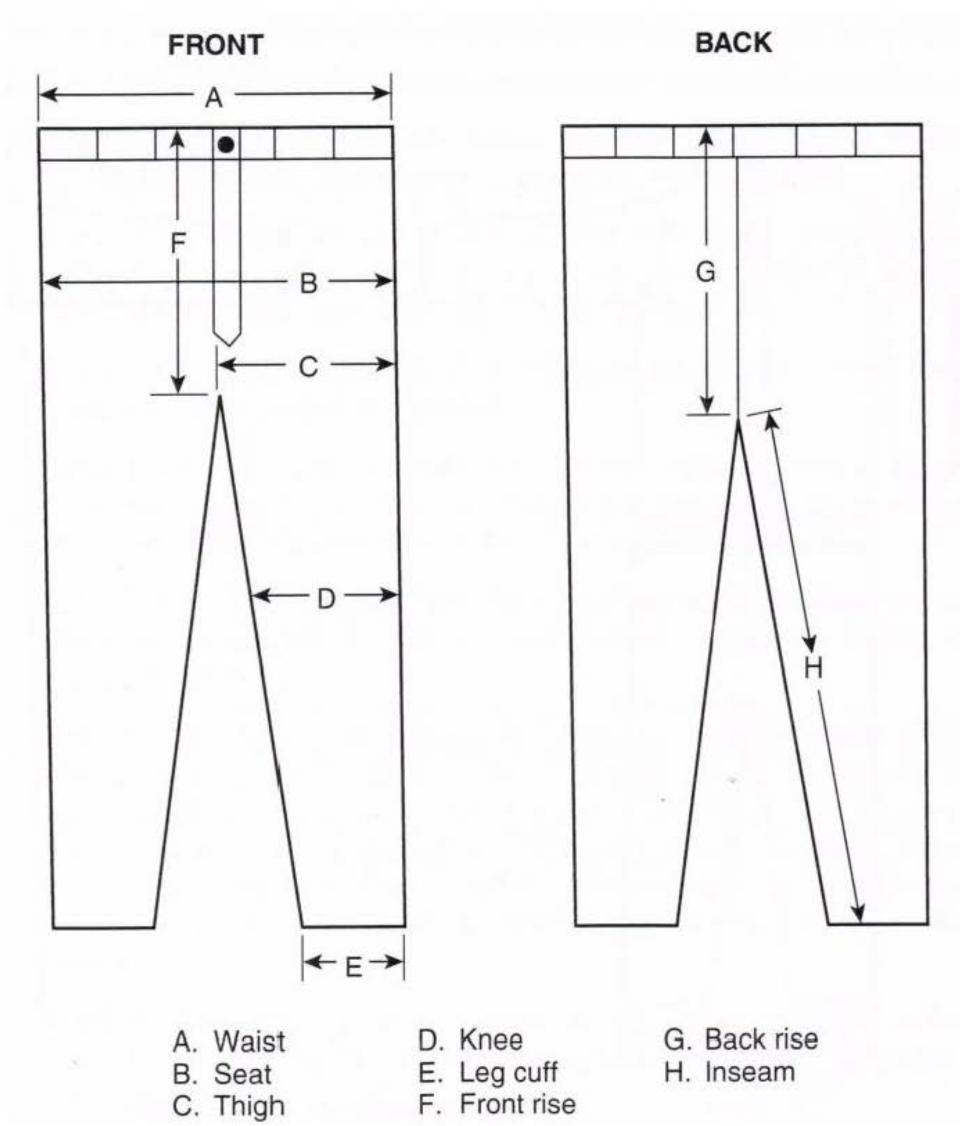
APPENDIX D – Case study 2 Questionnaire



If you would change or improve the comfort of your pant, what would offer you more comfort? Explain in detail.

Select all pant areas that you feel do not provide adequate protection. (If no problems you can skip the question.)

APPENDIX D – Case study 2 Questionnaire



Explain any of the pant protection problems that you selected above, if applicable. (If no problems you can skip the question.)

Select all areas that have durability problems on your pant. (If no problems you can skip the question.)

APPENDIX D – Case study 2 Questionnaire

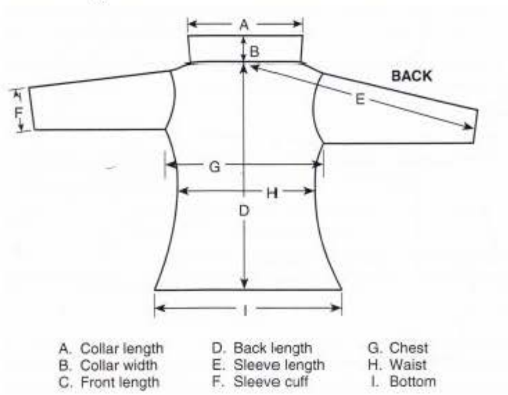
Legs	Knee	Front	Seat	Waist	Ankle	Crotch	Pockets	Seams	Buttons or Snaps	Zippers	Velcro	Elastic	Buckle
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Shirt

For the following questions, think about your wildland firefighting shirt you typically wear while working.

What size do you prefer to wear for your firefighting shirts?

Indicate your shirt fit satisfaction for each of the following areas:



	Extremely satisfied	Moderately satisfied	Slightly satisfied	Neutral	Slightly dissatisfied	Moderately dissatisfied	Extremely dissatisfied	Not applicable
A. Collar length	○	○	○	○	○	○	○	○
B. Collar width	○	○	○	○	○	○	○	○
C. Front length	○	○	○	○	○	○	○	○
D. Back length	○	○	○	○	○	○	○	○
E. Sleeve length	○	○	○	○	○	○	○	○
F. Sleeve cuff	○	○	○	○	○	○	○	○
G. Chest	○	○	○	○	○	○	○	○

APPENDIX D – Case study 2 Questionnaire

	Extremely satisfied	Moderately satisfied	Slightly satisfied	Neutral	Slightly dissatisfied	Moderately dissatisfied	Extremely dissatisfied	Not applicable
H. Waist	O	O	O	O	O	O	O	O
I. Bottom	O	O	O	O	O	O	O	O

If you could change the fit of the shirt, what would you change? Explain below. (If no problems you can skip the question.)

Is there a brand or manufacturer of wildland firefighting shirt that you prefer to wear? Explain why your prefer that brand/manufacturer over others.

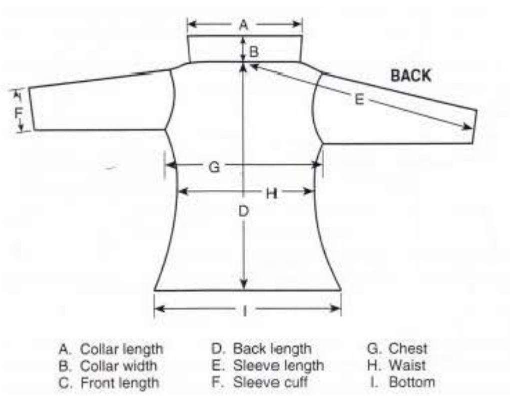
Select a location between the pair of adjectives at the location that best describes how you feel about your wildland firefighting shirt.

Comfortable	O	O	O	O	O	O	O	Uncomfortable
Acceptable	O	O	O	O	O	O	O	Unacceptable
Flexible	O	O	O	O	O	O	O	Stiff
Easy to put on	O	O	O	O	O	O	O	Hard to put on
Freedom of movement in arms	O	O	O	O	O	O	O	Restrict movement in arms
Like	O	O	O	O	O	O	O	Dislike
Loose	O	O	O	O	O	O	O	Tight
Sturdy	O	O	O	O	O	O	O	Not sturdy
Cold	O	O	O	O	O	O	O	Hot
Soft to the skin	O	O	O	O	O	O	O	Harsh to the skin
Machine washable	O	O	O	O	O	O	O	Not machine washable
Easy care	O	O	O	O	O	O	O	Not easy care
Durable	O	O	O	O	O	O	O	Not durable
High quality	O	O	O	O	O	O	O	Low quality
Breathable	O	O	O	O	O	O	O	Does not breath
Easy to remove	O	O	O	O	O	O	O	Hard to remove
Functional	O	O	O	O	O	O	O	Not functional
Lightweight	O	O	O	O	O	O	O	Heavyweight

APPENDIX D – Case study 2 Questionnaire

Non-irritating	O O O O O O O	Irritating
Low Static	O O O O O O O	High Static

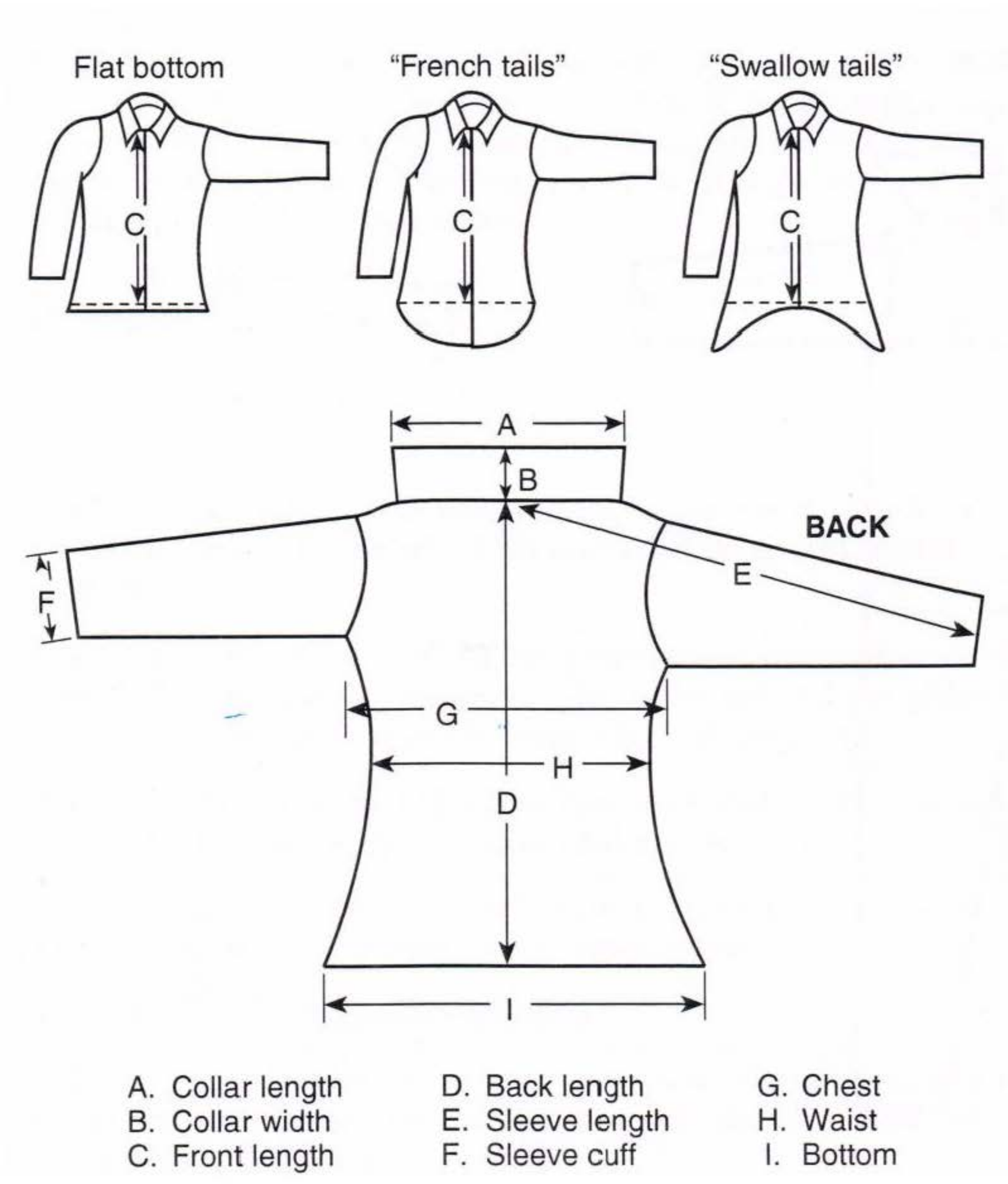
Select the areas which cause you problems with mobility while working. Click all that apply. (If no problems you can skip the question.)



If you would change or improve the comfort of your shirt, what would offer you more comfort? Explain in detail. (If no problems you can skip the question.)

Select all shirt areas that you feel do not provide adequate protection. (If no problems you can skip the question.)

APPENDIX D – Case study 2 Questionnaire



Explain any of the shirt protection problems that you selected above, if applicable. (If no problems you can skip the question.)

APPENDIX D – Case study 2 Questionnaire

Select all areas that have durability problems on your shirt. (If no problems you can skip the question.)

Arms	Back	Chest	Collar	Front	Cuff	Pockets	Seams	Buttons or Snaps	Zippers	Velcro
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

General

Have you ever experienced your equipment causing problems with your movement, comfort, protection, fit, durability, or so on while working in your firefighting apparel? Please explain in detail what problems you experienced. (If you have not experienced problems you can skip this question.)

Indicate your level of satisfaction with the design details on your firefighting apparel.

	Extremely satisfied	Moderately satisfied	Slightly satisfied	Neutral	Slightly dissatisfied	Moderately dissatisfied	Extremely dissatisfied	Not applicable
D rings	○	○	○	○	○	○	○	○
Buckle	○	○	○	○	○	○	○	○
Gear loops	○	○	○	○	○	○	○	○
Vents	○	○	○	○	○	○	○	○
Chest pocket size	○	○	○	○	○	○	○	○
Chest pocket location	○	○	○	○	○	○	○	○
Arm pocket size	○	○	○	○	○	○	○	○
Arm pocket location	○	○	○	○	○	○	○	○
Belt loops	○	○	○	○	○	○	○	○
Back pocket size	○	○	○	○	○	○	○	○

APPENDIX D – Case study 2 Questionnaire

	Extremely satisfied	Moderately satisfied	Slightly satisfied	Neutral	Slightly dissatisfied	Moderately dissatisfied	Extremely dissatisfied	Not applicable
Back pocket location	O	O	O	O	O	O	O	O
Pant slash pocket size	O	O	O	O	O	O	O	O
Pant slash pocket location	O	O	O	O	O	O	O	O
Thigh pocket size	O	O	O	O	O	O	O	O
Thigh pocket location	O	O	O	O	O	O	O	O
Crotch reinforcement panel	O	O	O	O	O	O	O	O
Reflective materials/strips	O	O	O	O	O	O	O	O
Back pleat	O	O	O	O	O	O	O	O
Contoured knees	O	O	O	O	O	O	O	O
Radio pocket size	O	O	O	O	O	O	O	O
Radio pocket location	O	O	O	O	O	O	O	O

Indicate your level of satisfaction with the closures on your firefighting apparel.

	Extremely satisfied	Moderately satisfied	Slightly satisfied	Neutral	Slightly dissatisfied	Moderately dissatisfied	Extremely dissatisfied	Not applicable
Buttons	O	O	O	O	O	O	O	O
Snaps	O	O	O	O	O	O	O	O
Zippers	O	O	O	O	O	O	O	O
Velcro	O	O	O	O	O	O	O	O
Zipper pulls	O	O	O	O	O	O	O	O
Pocket flap closures	O	O	O	O	O	O	O	O
Gusset ankle (zipper closure)	O	O	O	O	O	O	O	O

How would you rate the availability of your firefighting apparel when you go to purchase it?

Rarely Available O O O O O O O Always Available

APPENDIX D – Case study 2 Questionnaire

Where do you normally purchase your firefighting apparel?

- Online / Website
- Retail Store
- Mail order
- Employer provided

How affordable do you feel your firefighting apparel is?

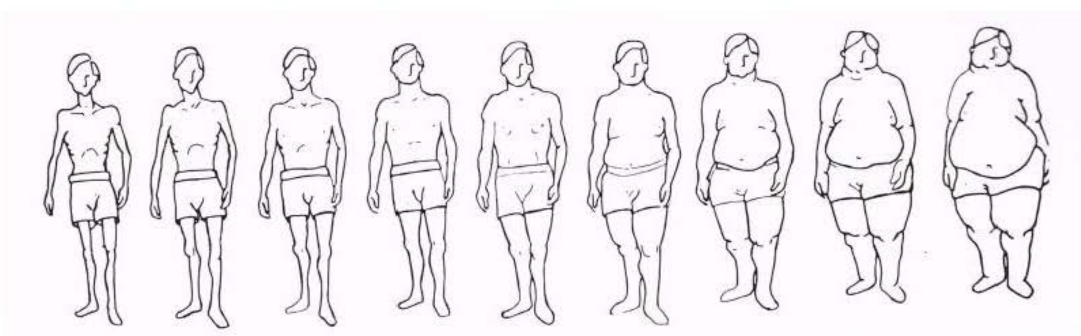
Not affordable ○ ○ ○ ○ ○ ○ ○ Very affordable

Body Shape

The next questions deals with body shapes. Please indicate your gender.

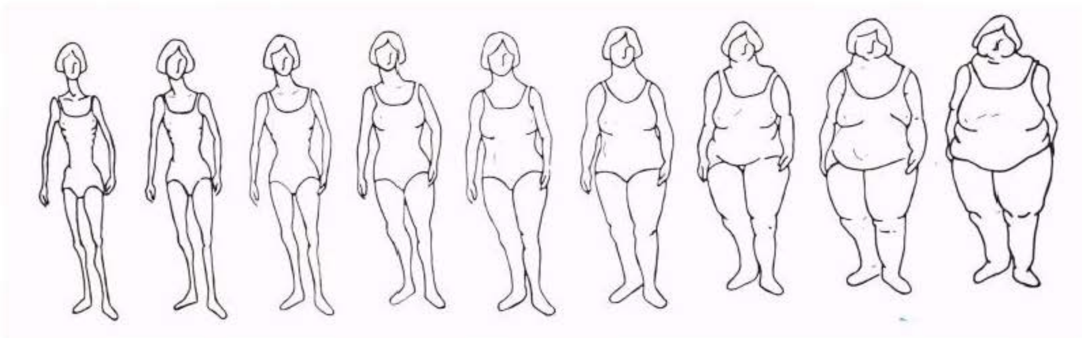
- Male
- Female

Select the body shape that most closely represents your current body shape.



Select the body shape that most closely represents your current body shape.

APPENDIX D – Case study 2 Questionnaire



Indicate your height and weight below for calculating BMI.

	Your information
Height (feet' inches")	
Weight in pounds	

Addtl Info

Is there any additional information we should know about how your firefighting apparel could be improved? Explain below.

Demographics

What is your age?

What is your occupation or title?

How many years of experiences do you have as a wildland firefighter?

APPENDIX D – Case study 2 Questionnaire

What is your ethnic origin?

- Caucasian
- African-American
- Hispanic
- Asian or Pacific Islander
- American Indian/Alaskan Native
- Other (please describe)

What is your marital status?

- Married
- Widowed
- Divorced
- Separated
- Never married

What is your family income level?

In which state do you currently reside?