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Dr. WHO?: The Science and Culture of Medical Wear Design

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A thesis submitted in partial fulfillment of the requirements for the degree of
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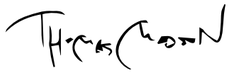

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CONTENTS

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THE MEDICAL UNIFORM

ABSTRACT

The multi-million-dollar medical uniform industry has not utilized advancements in garment and textile technology that could positively impact the protection of healthcare professionals and patients. In most cases the uniforms meet basic requirements – they clothe the professional in a recognizable way. Little innovation in design, function and performance, has been applied to these garments. This is particularly evident in the case of the stereotypical white lab coat worn by many physicians, despite evidence indicating that these lab coats may carry contamination and play a role in the spread of deadly bacteria. Healthcare Associated Infections (HAIs) are among the most serious problems facing modern medical care, costing millions of lives and dollars annually worldwide. This research investigates the design and use of the physician's lab coat – an immediately recognizable symbol of Western medicine. The research identifies the medical, functional, cultural and symbolic roles of the lab coat within the hospital environment and beyond, to the larger the global society. This thesis examines the extent to which the design of medical wear can impact the effect of hospital-acquired infections, support doctor/patient relationships and enhance the performance and behavior of the healthcare professional by envisioning a future lab coat which which offers increased protection for physician and patient, aids in communication and enhances the performance of the doctor by utilizing digital technologies incorporated into the lab coat whereby the lab coat becomes the only tool necessary for the physician.

PREFACE

INTRODUCTION

As principal investigator of a large-scale project to design the clinical wear uniforms for the new Sidra Medical and Research Center in Qatar, I discovered that the field of medical uniforms is characterized by a lack of innovation almost unheard of in the fashion industry. Much of the literature on medical uniforms focuses on the policies, symbolism of uniforms and is undertaken by standards authorities and the medical profession.[1] In contrast the research carried out by uniform manufacturers is lacking; and what design-based research there is, has typically been developed with only minimal input from the people who will wear the end product.[2] Within the design industry, professional garments such as medical uniforms are designed to accommodate the existing manufacturing capabilities of the producer, which can limit a critical design approach and innovation.[3] One consequence of this is the lack of focus on garment performance, resulting in a classic fashion approach offering seasonal product updates that have minimal aesthetic variations, typically changes only in color and simple styling details. Manufacturers tend to stick to tried and tested fabrics, working with the same materials and textile makers who produce cloth consistently year after year. Having served both as an in-house fashion designer at a garment manufacturer and as a client, I am aware of the commercial limitations placed on designers. In the commercial world garment cost is the bottom line, and if a design threatens profits it is typically either disregarded or is stripped of its expensive components to achieve the price target. Price targets are dictated by previous selling prices and competitor prices. All of these factors combine to create a heavily standardized market of commercial designs. The aim of this research is to creatively investigate design options for a medical uniform, in this case the physician's lab coat, and develop a conceptual prototype that will break free of the bonds of market standardization to present a garment that is designed to assist physicians in carrying out all aspects of their role. Data for this research was collected through a triangulation of personal observation, interview and document review with informants medical professionals, administrators, textile engineers and garment manufacturers.

BACKGROUND

The physician's lab coat and clothing has been the subject of much debate. The "bare below the elbow policy" (BBE) was introduced by the UK's Department of Health in 2007 to tackle nosocomial infection, and banned the wearing of wristwatches, neckties, and long sleeves for clinicians. However, the same research found that physician's neckties are worn repeatedly and rarely cleaned; making them the perfect substrate to carry bacteria from patient to patient as physicians go about their rounds. Watches, moreover, are susceptible to contamination for the same reasons. In addition, long sleeves were deemed a hindrance to the vital exercise of hand washing. However, C. A. Willis-Owen, et al carried out research in 2009 to examine the effect of the policy on the presence of bacteria on doctors' hands and concluded that there was no significant difference between the presence of bacteria on the hands of the doctors who were compliant with the policy and those who were not.[4] However, other research has found that what doctors' wear has an important psychological effect on patients. Subramanian, et al, demonstrated that patients perceive the BBE-compliant uniforms as unhygienic; thus, the patients' confidence in the doctor may be undermined. What doctors wear can influence a patient's perception of the clinician, which in turn may influence whether patients follow a doctor's advice. Formal attire has been shown to instill greater confidence and trust in patients. Questions have arisen as to whether a doctor's clothing can impact the patients' decision to attend follow-up consultations and consume medicine as prescribed.[5] However, C. A. Willis-Owen, et al, argue that the findings, which led to the legislation are flawed and they recommended that more critical research be done, including an examination of the uniforms and textiles as a source of contamination.

The popularity of the white lab coat has actually decreased significantly since its adoption in the early 1900s. In 1991, studies in the United States indicated that more than 70% of hospital doctors and medical students wore a white coat more than 75% of the time.[6] More recently a 2004 study indicated a large reduction in the number of physicians who chose to wear a white coat at only 13% of the physicians in the study.[7] The studies indicate that the main reasons for this change included infection risk, discomfort, and interference in the physician-patient relationship. In 1991, 294 medical students and physicians in London were asked to explain why they wear the lab coat on the basis of personal priorities. The responses of 25% of respondents stated easy recognition by colleagues and patients followed by 23% stating the need to carry medical instruments, and 15% stated to keep their clothes underneath clean. However, when assessing the results, it is important to note that only 29% of the study population actually wore the white lab coat (82% of the doctors were working in pediatrics and psychiatry). Reasons for not wearing the coat included avoiding a negative impact on patients. Interestingly, research suggests that even with the decline of popularity in wearing the white coat among physicians, it is still desired by many patients. In another study, 56% of patients favored doctors wearing white lab coats.[8] Similar results were obtained during a study of 168 patients from three teaching family medicine clinics in Israel, in which 52% of the patients preferred a physician in a white lab coat because it signaled a trustworthy profession.[8] It is evident that there are inconsistent theories for or against the use of the lab coat, it is clear that there are personal and professional preferences which influence the decision making however if a lab coat is worn, it should function in ways that support both the doctor and patient, offering protection, comfort, and reassurance to both parties.

DESIGN PROCESS

A system such as the medical garment industry has a long and conventional history including multiple stakeholders. The complexity of this system requires cognizance of many disparate perspectives and agendas when approaching the design of a product such as the physician's lab coat because the garment is a symbol of this system and is therefore deeply embedded in history and meanings determined by the system. In order to work my way through this conceptually I used a mind map to arrive at three main topics for investigation, each of which links to multiple subtopics and stakeholder groups for consideration. These areas of investigation are presented below. These topics have become the subject matter for the body of my thesis research. I then applied design thinking to work with this information. See Figure 1

Buchanan, a widely recognized professor at the Carnegie Mellon University School of Design, describes design thinking as a process, "by which a designer intuitively or deliberatively shapes a design

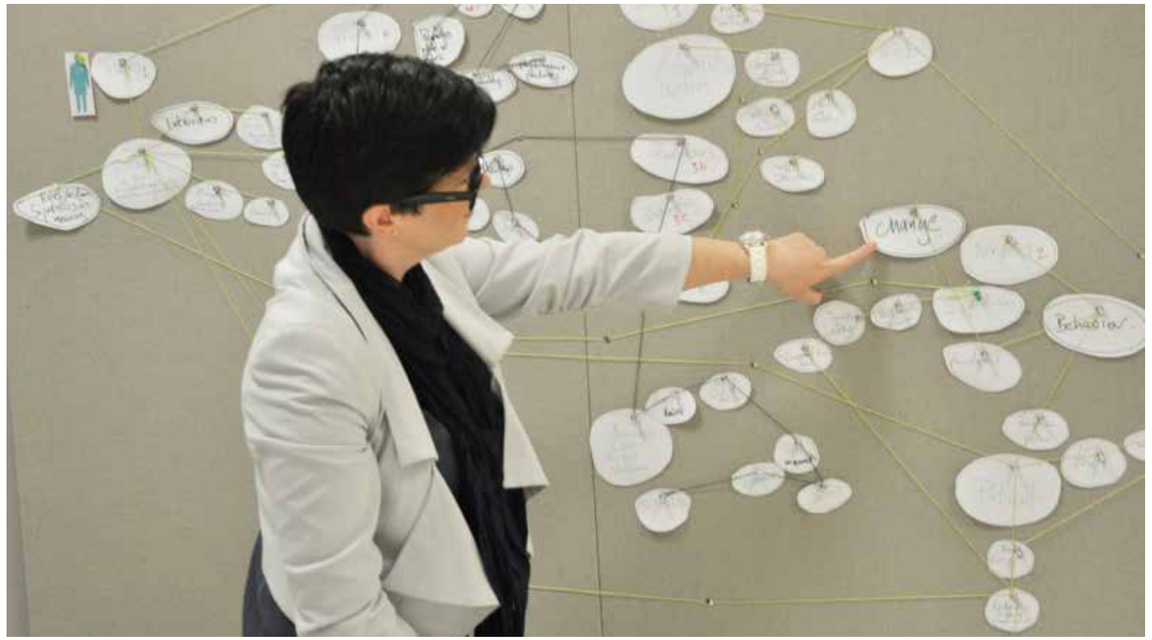


Figure 1 Mind map of lab coat stakeholders, VCUQatar, Al Rayyan, Qatar (2014)

situation, identifying the views of all participants, the issues which concern them and the invention that will serve as a working hypothesis for exploration and development".[10]

In this research I used design thinking to gain a deeper understanding of the subject matter in order to determine the feasibility of changing the design of the medical uniform. More specifically, I analyzed problems related to the current uniform and examined the background and history of the physician's uniform to identify common dominators and factors to be addressed in the redesign of the lab coat.

Main Topics of Investigation

01	**Symbolism**	meanings and definitions communicated by the product
02	**Product**	physicality of the garment
03	**User**	physicians
04	**Hospital**	systems

DESIGN PROCESS

THE LAB COAT AND THE SYMBOLIC PRESENTATION

A question that continually arose as I began to understand more about the role of the doctor's uniform was: **how much change could I make to the lab coat without eroding its benefits to physicians, patients and society as a whole in terms of its status as an internationally recognized symbol?** This led me to question why and how the lab coat has become one of the most recognized symbols of medical doctors? I realized that I needed to examine my subject matter in terms that reached beyond materiality to understand the uniform from a more holistic perspective.

The impact of clinical wear symbolism is readily apparent in the physician-patient interaction. The physician-patient relationship is the foundation for all medical care. Research suggests that a patient's initial consultation plays a fundamental role in the development of this relationship.[11] During this consultation, the patient will develop a first impression of the physician based on a number of factors including the physician's verbal and non-verbal communication as well as personal attributes such as clothing, accessories, grooming, and cleanliness.[12] As far back as the 400s BC, the ancient Greek physician Hippocrates recommended that doctors should "be clean in person, well dressed, and anointed with sweet smelling agents."[13] Hippocrates's prescription suggests that how a doctor looks (and smells) has been important at least since the dawn of Occidental medicine.

D. W. Cathwell, MD, wrote the first edition of **The Physician Himself**, a book to guide doctors in all aspects of their role as physicians entering the medical profession. The first edition of the book was written in 1882 and revised with multiple editions published between 1882 and 1922. Cathwell advised, "Show aesthetic cultivation in your office arrangement, and make it look fresh, neat, clean and scientific."[14] Even at the earliest understanding of the doctor's profession, it was clear that not only were the physician's physical appearance and attire important, but also the state of his/her surroundings, each shaping social interaction in a distinctive manner. Multiple factors influence patients' perception, which promote a relationship of trust between doctor and patient.

The color white has not always been the obvious choice for the lab coat. In fact, doctors didn't even wear lab coats in the 19th century. The doctor's dress at that time consisted of formal attire for all clinical activity, including surgery. Doctors attended the sick

Figure 2 Eakins, Thomas. "The Gross Clinic", Oil on canvas, 240 cm × 200 cm Surgery carried out by Dr. Samuel dressed in black layman's clothes, 1875.

in their homes, not in an institution. During this period, there was no understanding of the concept of bacteria and its role in the spread of infection. Doctors' status, as it is today, did not exist prior to the 19th century, when doctors were mostly indistinguishable from other types of healers with their various forms of rituals and dress. To become a doctor was relatively easy; a medical degree could be obtained in a year. Scientists in laboratories wore tan colored lab coats to make dust more visible, and black lab coats were worn in mortuaries as

Figure 3 Eakins, Thomas. "Agnew Clinic", Oil on canvas, 2.14 m x 3.0 m depicting Dr. Agnew in surgery carried out in white clothes 1889.

a garment to protect the wearer from various forms of dirt and bodily fluids encountered during certain procedures.[15] It is believed black was used in recognition of the somber nature of the work carried out. Louis Pasteur, the French chemist and microbiologist, proved the germ theory in the mid-1800s, which led Joseph Lister to develop antiseptic methods in surgery, a major scientific development that revolutionized medical care.[16] The white lab coat was introduced into the operating theater to protect the patient from being contaminated by the physician and to protect the physician from being contaminated by the patient while surgery was being performed. Following the discovery and proof of germ theory, a major force in adopting the white coat, which has since become synonymous with the medical profession, was the shift in sick care from home to hospital. This occurred because it became too difficult to create a sterile environment outside the hospital and was impractical to bring the necessary equipment into peoples' homes. Therefore, hospitals began to adopt the color white for all uniforms related to healing during the early 1900's. During this period, medical schools also adopted a more rigorous and standardized curriculum and physicians became scientific in their practice and dress.

DEVELOPMENT OF HISTORICAL SYMBOLISM

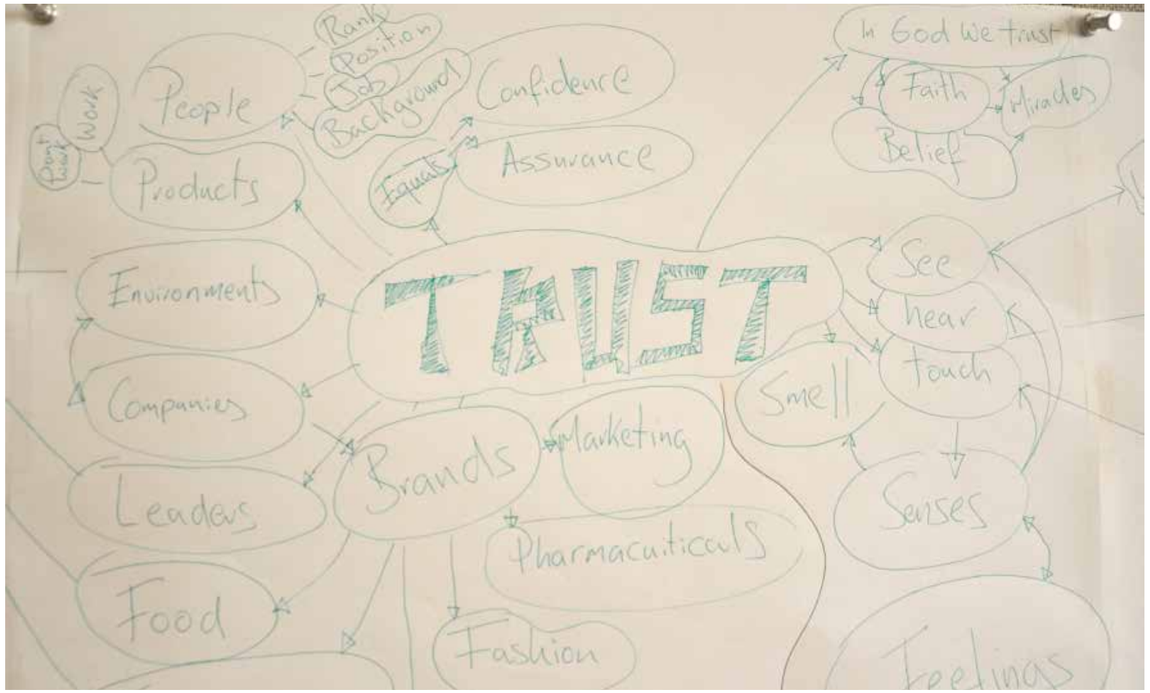


Figure 4 "Trust" Mind map, pen on paper, 2014.

Just as the social function of the physician has evolved over the past century, so has the lab coat. The color white commonly symbolizes cleanliness, purity, and the scientific foundation of the medical profession. Science, with its ability to defy common beliefs and advance the world in ways not previously seen or thought of, became the basis of the medical profession at the turn of the 20th century when the benefits of sanitation and clean water were recognized in conjunction with the introduction of the antiseptic theory.

Dr. Byrad Yelland, sociologist and Assistant Professor at VCUQatar, explained that a uniform acts on a number of levels. The existence of a uniform implies a group structure. The uniform indicates membership in the group, which represents and embodies the attributes of an organization. The white lab coat therefore acts as a symbol.[17] Admission to a group can be symbolically recognized during ceremonies when the uniform and its accessories are presented to the newly qualified professional. In many professions, these symbols are recognized as a sign of having proved worthiness to enter the group or rank that goes with the uniforms for example the nurse's pin, the policeman's shield, army stripes, soldier's honorary medals, academic robes and lawyer's wigs. Rituals include the graduation ceremony, which formally acknowledges admission into an elite group and acceptance of what the group stands for. More than 100 medical schools in the US mark the transition from medical student to a qualified physician by holding a white coat ceremony (WCC), a ritual signifying the right of passage into the medical profession. D. W. Blumahagen and others have identified cultural symbols as a form of communication, analogues to spoken words in a natural language.[18] In fact, words are symbols. The word "chair" is not a chair, it is a symbol used to represent a chair during communication. Symbols are developed in congruence with the definitions and meanings held by a social group whether it be a small

Figure 5 George Clooney, TV series ER

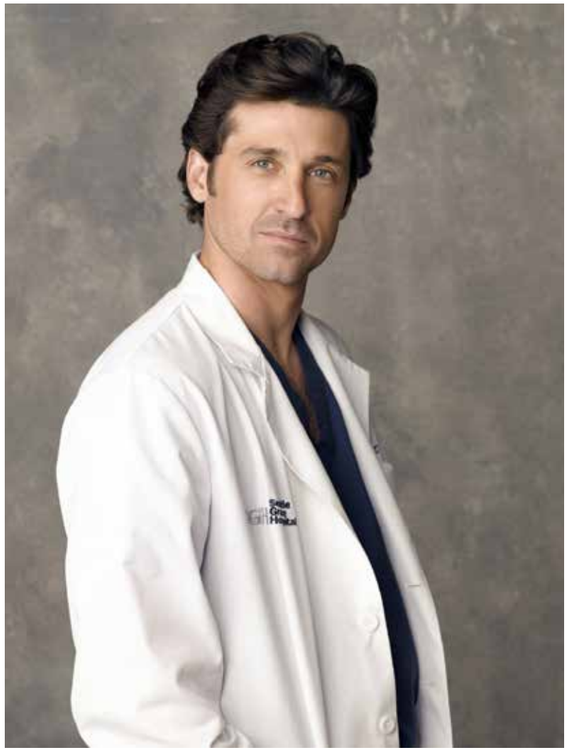


Figure 6 Patrick Dempsy, TV series Greys Anatomy

Figure 7 Ellen Pomeo, TV series Greys Anatomy

clique or a larger society. As such, symbols express and reaffirm the fundamental belief systems of that group.[19] The white lab coat is symbolically associated with the definition of physician in Western-based medicine and, in fact, is the most frequently used object when representing a physician in a variety of media including advertising and film.[20]

Dr. Yuelland explained that in dramaturgical sociology, one could consider the elements of human interactions as dependent upon time, place, and audience. In the same way language is used in a social setting to define a shared interpretation of reality, the uniform assists the wearer in an actor-like fashion to be seen as a character playing a role and therefore behaving in pre-determined and scripted ways. Symbols such as uniforms also enable others in the society (audience) to understand what they can expect from the actor in that role. In other words, seeing someone wearing a white lab coat in medical setting signals to us that this person is a medical professional, likely a physician, and we can expect certain types of behaviors from that person.[21] In this social drama, the uniform or costume can also express hierarchical relationships amongst the individuals who are interacting. But why have these symbols relating to doctors become so prevalent and powerful?[22]

"Symbols are social objects used to represent (or "stand in for," "take the place of") whatever people agree they shall represent…holding two fingers in the air stands for victory (or peace, or loyalty to the

Figure 8 Doctor Characters, TV series Grey's Anatomy

Boy Scouts)".[23] Symbols are tools for expressing and reaffirming fundamental belief systems of a society. Studies have examined symbols commonly deployed to represent the doctor and have identified four defining objects: **the white lab coat, stethoscope, head mirror and black bag**. Of all the symbols identified, the white lab coat was found in use most frequently.[24] Importance of the white lab coat as symbol par excellence of doctors can be seen in a variety of media including advertising and film, which often reflect social stereotypes. As far back as the early 1900's the emerging film industry began to represent physicians as characters of immense power.[25] The doctors eventually achieved a god-like social status as a result of the surgeon's power to anesthetize the patient and carry out procedures that in any other circumstances would be deemed as violating the body. In this instance, the lab coat served to legitimize behavior that was otherwise considered socially taboo. With this, a message of power and protection emerged and physicians quickly became stereotyped as scientists wearing white coats.[26]

The trend continued on in the 90's, George Clooney became one of the most popular and recognized actors due to his role as a physician in the popular U.S. medical drama **ER. Scrubs** and **House** are two other current popular television series that are aired internationally and portray doctors as central characters. Physician's characters in television series are usually portrayed wearing a white lab coats worn over their clothes underneath. See Figure 5 and 8

PSYCHOLOGICAL DYNAMICS OF THE LAB COAT

So why is it so important that the doctor be recognized as such by his or her patients? In the article, " The doctor's white coat," D. W. Blumahagen explains that the relationship between patient and doctor is "serious and purposeful, not social, casual or random."[27] A patient must bare himself or herself in front of a doctor in a deeply vulnerable way. This type of situation does not exist in any other form of communication or experience. In many disciplines formal attire is worn for serious business in the same way casual attire is often worn for less serious business or leisure time.

J. P. Kriss, a physician and educator, articulated the need for appropriate physician' attire in the article "On White Coats and Other Matters", explaining, "The physician's dress should convey to even his most anxious patient a sense of seriousness and purpose that helps to provide reassurance and confidence that his or her complaints will be dealt with competently."[28] Confidence in one's physician is crucial because the medical process requires patients to share intimate knowledge about themselves in order to receive treatment. This process can also require the patient to bare all or part of the body to the physician and allow the

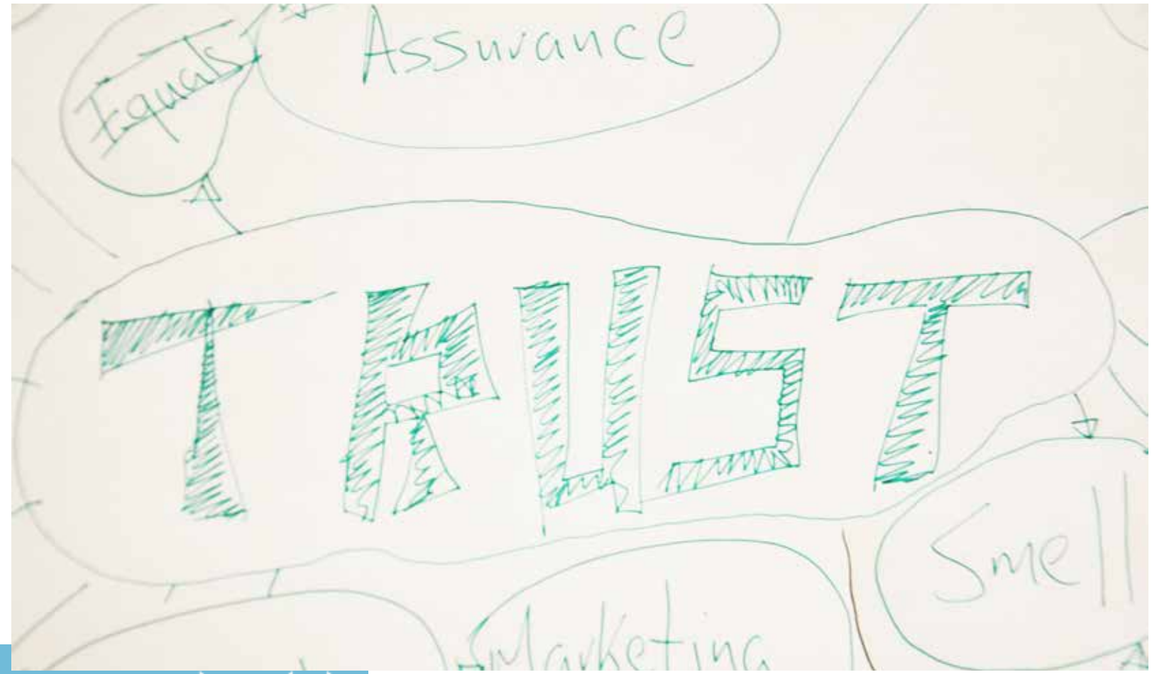


Figure 9 "Trust" Mind map, pen on paper, 2014.

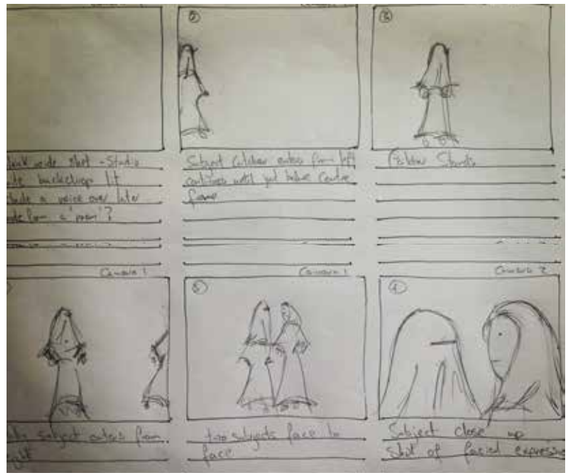


Figure 10,11 "Trust Fall" Sequential storyboards, pencil on paper, 2014.

physician to observe, touch, and even cut into the patient's physical self, all of which are intensely intimate acts.[29] On the other hand, the physician is required to ask questions about intimate topics, observe parts or all of the patient's body and perform medical procedures upon the patient's body. All of these acts are profoundly intimate at a physical level yet must occur while maintaining an emotional distance. This inherently contradictory relationship places both parties into some degree of vulnerability, enhancing the need for a strong feeling of trust.

Many studies have examined the perceptual effect the doctor's appearance has on the patient and have confirmed that patients do care about the appearance of their doctor. It has been shown that patients may unconsciously evaluate the doctor's competency and credibility on the basis of how the physician's physical appearance. A study of parents of children admitted to a pediatric ward of a university teaching hospital in America discovered that they were twice as likely to attribute confidence to doctors in formal clothing compared to doctors in casual dress.[30] In a similar study 76.3% of the 400 respondents said they preferred the use of a white lab coat.[31] Interestingly, patient trust and confidence were significantly linked to their preference for professional dress. On this very point, Dr. Guy Brisseau Chief of Pediatrics in Sidra Hospital in Qatar reflected on his time teaching trainee doctors and remarked that sometimes they would arrive to class wearing casual jeans and t-shirts. He considered this as inappropriate attire and he sent offending students home to change into more professional clothing that more aptly projected the doctor's professional image.[32] However, research has also highlighted that there are discrepancies between patients' perception and signification of the lab coat and the reasons doctors choose to wear or not wear one. . Many culturally progressive Western psychiatrists and pediatric doctors, tend not to wear the lab coat, reporting that it inhibits the relationship between patient and doctor because it may intimidate the patient. In this context, doctors often choose to wear pastel coats or normal clothing. Another factor in patient preference for formal attire is age. In a study to assess patients' preferences, patients over the age of 40 preferred doctors' formal attire, whereas younger patients were less concerned. Interestingly, the preference for more conservative apparel is age-related for doctors as well as patients. Doctors in more senior positions and over the age of 40 prefer more conservative, traditional dress. However, this trend is a predictable reflection of the normal behavioral shift associated with ageing rather than the specific phenomenon related to the doctors' appearance. Some studies show that patients actually felt more relaxed about the appearance of physicians than the physicians themselves.[33] There is a significant difference of opinion surrounding the discussion of doctor's attire, with the lab coat tending to occupy the focus of much discourse. The current lab coat offer in the market is lacking in a number of areas including aesthetic, performance and functionality. This research also suggests that there is not one solution that will suit all cases; there is a need for a flexible uniform option that supports the individual needs of the doctor and the expectation of the patients he/she attends. This thesis will present an alternative that meets the needs of the physician and patient.

SUMMARY

As my research strongly suggests, the white lab coat has become a powerful and pervasive symbol of trust in society in general and the medical profession in particular. To further my understanding of trust, I staged a scenario to observe trust in action during my studio class. Intentionally, I avoided grounded theories relating to trust in terms of risk versus gain and the relationship between the principal and the agent. I wanted to examine trust in a raw state, in its most basic and primitive form in order to visualize the feeling. The situation needed to be one in which the risk was not too high but also gave me the opportunity to see how the participants would assess risk in a particular situation. There are particular conditions needed for trust to exist.

INVESTIGATION

INVESTIGATION I

Figure 12 Studio set up

Figure 13 Studio set up

Figure 14 Studio set up

After brainstorming a number of ideas, I decided upon the classic trust fall that is commonly used as an exercise in team building. Research confirmed that many of the conditions that promote trust include familiarity, understanding, recognition, repetition, and knowledge. In short, people trust what they know. With this in mind, my intention was to engineer a scenario in a way that could eliminate some of the conditions associated with trust as part of the experiment so that I could examine the situation and further understand the human condition in relation to trust.

I designed the scenario in detail with the subjects' positions clearly marked, cameras poised, and a practice run conducted with Hadeer Omar, a graphic designer who kindly assisted me in setting up, editing the video, and being a volunteer herself. See Figure 14.

Criteria:

01 No Intsruction	04 No Prior Knowledge
02 No Demonstration	05 No Familiarity
03 No Discussion	06 No Repetition

Figure 15 Trust Fall

Figure 16 Trust Fall

Figure 17 Trust Fall

Figure 18 Trust Fall

Figure 19 Trust Fall

Figure 20 Trust Fall

I chose seven volunteers, all of whom were female VCUQatar students who wear the Abaya a black piece of clothing that is commonly worn to hide the clothing underneath). **See figure 15-20.** This choice was made to include volunteers of the same sex, of similar status, religious and cultural values. Mixing the sexes in an exercise such as this would not have been appropriate within the Islamic culture. Some of the volunteers already knew each other. In fact, recruiting the volunteers worked better when the two (catcher and faller) were recruited together. This confirmed research that indicates familiarity could promote a sense of trust. Knowing the person who was catching you indeed helped in easing the anxiety of the fall. One volunteer pointedly remarked how she was glad she knew her catcher.[34] In the case of a physician meeting a patient for the first time there is no prior knowledge and makes it even more important that the appropriate conditions exist that help support trust in the relationship including what the physician is wearing.

To capture specific angles and details on camera including facial expressions, gestures and actions, some instruction was required. On the one hand, I had to direct the couple, and on the other, the couple needed to interact naturally by asking questions and discussing things between themselves about how the action would play out and what each would do as part of the act. This interaction also confirmed the theory that having information regarding the situation helps to promote trust amongst participants. It had been my intention to shoot one continuous scene for each couple, but due to the variety of camera shots required, in reality we shot two to three times to get enough footage. Originally, I felt this would make the video look contrived and inauthentic, resulting in the scenario looking rehearsed, but in fact it actually displayed the importance of repetition, one of the main characteristics involved in forming trust. It was clear from talking to the participants that they felt more comfortable assuming the risk with each additional fall. This is evident in the facial expressions of the participants. Another interesting aspect I had not considered was the emotions of the catcher. One volunteer stated she felt far more nervous catching somebody due to the responsibility she felt to the other person, feeling less nervous when she was actually doing the fall herself. **See Figure 20.** This demonstrates the concept of responsibility and the feWelings associated with it are very powerful.

The outcome of the experiment provided first hand knowledge of trust but also insight into the relationship between two people. The scenario, in a way, metaphorically represents the doctor-patient relationship, where the patient trusts the doctor by literally putting themselves in their hands. It begs the question that if the lab coat is used as a symbol to represent trustworthiness, and in so doing acts as a tool to facilitate and reinforce the relationship between patient and doctor, how much can the design be altered and still represent its symbolic meaning or is there something else that can act in the same way?

PRODUCT PRECEDENTS

INVESTIGATION II

The classic medical lab coat has existed for over 100 years and has changed very little during that time. The garment appears almost exactly the same as it did when it was first introduced to the medical field in the early 1900s. Many professionals in the clinical setting wear a white lab coat, including nurses, lab technicians, and educators. The coats look very similar, the length being the only significant change. The doctor's lab coat consists of a number of common features. The color is always white it is usually mid-thigh to knee in length. Student doctors in the USA wear a short coat akin to a blazer.[35] Aesthetically, the silhouette of the garment is similar to the classic tailored, men's blazer or overcoat. The shape of the collar is a revere in style, which is also synonymous with a men's formal overcoat or blazer. The collar has a two-piece construction, which is folded back on itself to sit along the neck edge, which aesthetically frames the neck. The coat is single breasted. It has a button down front and is fastened using a classic button through method. The mechanism usually consists consisting of five plastic dyed to match buttons sewn to the base cloth in a single line with equal spacing. The edge of the button is placed so that when it is fastened through the buttonhole, the button secures the two fronts together symmetrically, vertically, and horizontally.

The appearance of lab coats for men and women are almost identical; however, when the coat is fashioned for the male, the front closing has a right side over left side fastening whereas the female version has a left over right fastening. This is a systemic and consistent feature in the construction of all garments with front openings, and sometimes this feature is the only method to identify if the garment is intended for the male or female. However, sometimes the lab coats on offer for doctors are unisex in style. In this case the fastening is constructed as the male closing and the fit of the garment is also tailored for a male shaped body, which is more cylindrical thus less fitted and less flattering on a female shape. This exaggerates the ill fitting appearance which in turns looks untidy and unflattering.

In general, lab coats share a similar set of traits, including one chest patch pocket placed on the left hand side as worn, which serves as a placeholder for a pen and or a hospital identification badge required by all medical staff. This badge is a source of contention due to its location, and its potential as a source of contamination due to the frequent handling and thus its' susceptibility to contamination, each time it is removed and applied to the freshly laundered lab coat. There are two larger front pockets on the lower part of the garment to allow the wearer to carry equipment or personal belongings. The garment's construction process is also the same way as it was in the 1900s, the method of cut and sew creating a garment using two (2D) dimensional textiles that are cut into shapes and sewn together to create a three dimensional (3D) form.

Sleeves of the lab coat are constructed in a set in method, long in length with a single underarm seam. The front panels of the garment are attached to the back panels with classic vertical side seams and shoulder seams. The garment sleeves and body are finished with a stitched hem at the bottom edge using an over-lock stitch and single needle stitch or clean finish hem. The back panel has a vertical center back seam running from the neck to the hem. In some garments the center back seam has a slit, which is added to provide additional ease when walking.

The classic process to manufacture a lab coat includes a number of steps:

01 Base cloth is woven

02 Construction patterns are created

03 Pattern pieces are laid on the cloth

04 Garment panels are cut

05 Panels are sewn together to construct the garment and care labels are sewn into the side seams

06 The garment is finished, pressed and packed

07 Quality assurance checks happen periodically throughout the production process

INVESTIGATION III

Figure 21 Visual storyboard of uniforms

To gain a greater understanding of uniforms and their associated meanings, I researched uniform aesthetics to examine how symbols are used to create understanding and communicate messages. I collated a list of attributes associated with the doctors' profession to see how these could be physically represented through the uniform.

Attributes

Professional, educated, wise, powerful, competent, trustworthy, hygienic, approachable, clinical, authoritative, empathic, responsible, respectful and precise.

Many professions have qualities that can be productively compared with the medical profession, including the military, clergy, pilot, airhostess, police, educators, superheroes and athletes. To visualize the findings, I collected visual references of various types of uniforms, to form a visual dictionary. The images articulate meanings through the aesthetic properties of uniforms. Grouping the imagery by profession I began to identify similar physicality's, including colors, trims, accessories, shape and style, each adding to the meaning and communicating messages about the person wearing the uniform. Using the storyboards I further analyzed and identified various properties of different uniforms that could also be attributed to the doctors' profession.

Figure 22 Visual storyboard of uniforms

Figure 23 Visual storyboard of uniforms

Figure 24 Visual storyboard of uniforms

Figure 25 Visual storyboard of uniforms

Figure 26 Visual storyboard of uniforms

The aim of this investigation is to understand if garment details could be used in an abstracted way to portray similar meanings in a different type of garment. To do this I selected a number of details that could be extracted and used as inspiration for an experiment to examine whether design details alone could provide meaning to a garment. Some features were consistent across multiple groups. Rank, position, authority, power and hierarchy, are often represented by gold braid, epaulettes, gold accessories, special pins, badges, multiple stripes, colored tapes, stars, wings, jewelry, elaborate metallic embroideries and hats. Uniform colors predominately consisted of combinations with black or navy or red and white. Other common styling details included stripes, piping, gold accents, bright color pops, body conscious silhouettes, stitching detail, exaggerated seaming, capes, technological looking fabrics and quilting. These details were consistent, indicating the likelihood of consistent themes within garments for physicians.

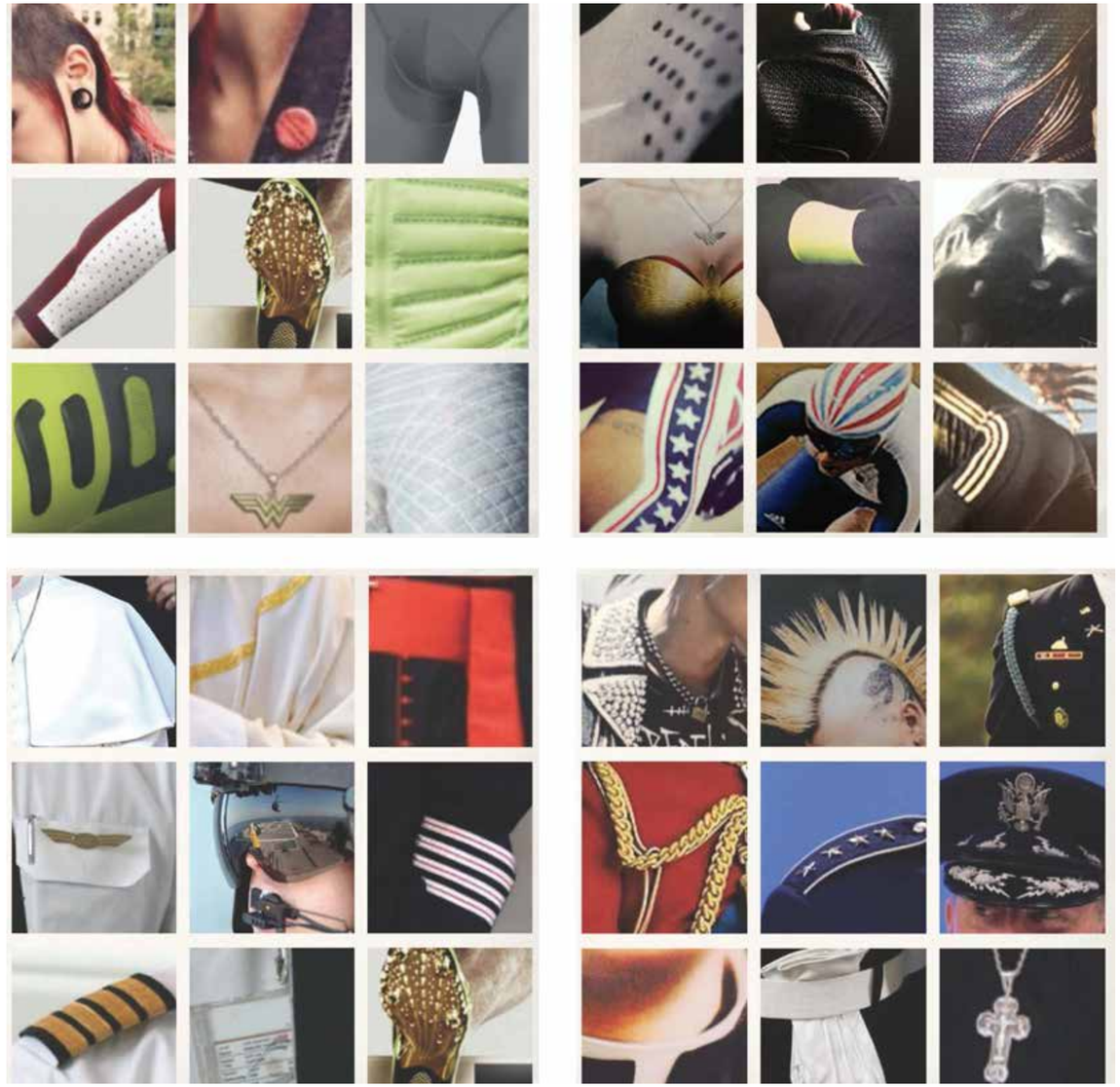


Figure 27 Extrapolated images of significant detailing of uniforms

INVESTIGATION IV

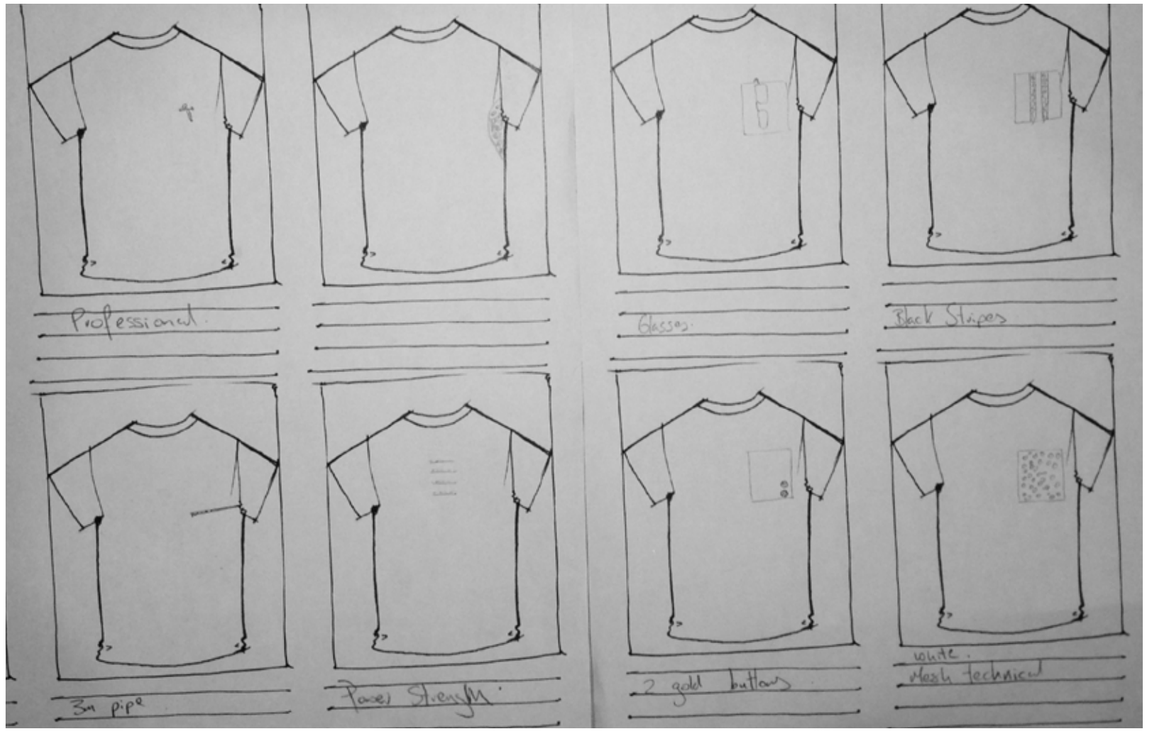


Figure 28 Initial concept sketches highlight design details on T-shirts

The selected styling details are significant commonalities in a variety of uniforms. Taking these details as a starting point I began sketching ideas for t-shirts. The first set of sketches appeared obvious and literal so I developed further ideas. In order to understand the meaning of the symbols I abstracted styling details from traditional uniforms and applied them to white t-shirts to investigate whether the meaning of the details would be understood on another type of garment.
After a period of one week and multiple iterations of the t-shirts, I settled on nine concepts to develop into prototypes taking each detail and deciding on materials, trims, manufacture methods to create the details on the T-shirts.

Figure 29 Prototype development of concepts with design details on T-shirts

Figure 30 Prototype development of concepts with design details on T-shirts

Using the nine prototypes, I created an installation and invited an audience of VCUQatar professors, visiting lecturer Alice Twemlowe and VCUQatar students to attend a focus group to examine the samples and write adjectives they felt described the meaning of the details for each T-shirt. I did not explain the concept or research to the audience prior to the exercise. This installation created an exciting interaction from the participants yet their comments also indicated a strong feeling was one of confusion. The comments heralded a number of adjectives yet these comments did not have the desired effect in terms of symbolic representation as norms for understanding. The meanings I had hoped they would represent had been lost in translation between the base garment and the abstracted details. On the other hand, this experiment extended the data collected through secondary research and helped me understand the importance of context in understanding meaning. A uniform is only part of the whole, for the uniform to have true meaning the environment surrounding it, with the person wearing it and the behavior of that person all contribute to the meaning of the uniform. All of these components must work in tandem to present an image that is understood by society.

Figure 31 Installation of t-shirts to host focus group. Dec. 2013.

Figure 32 Focus Group, audience participation Simone Muscolino, Alice Twemlowe, Diane Derr and Richard Lombard. Dec. 2013.

Figure 33 Focus Group, audience participation. Dec. 2013.

Main Themes:

- **Professional**
- **Athletic**
- **Technological**
- **Strength**
- **Powerful**
- **Authority**
- **Casual**
- **Rank**
- **Sterile**

INVESTIGATION V

Industry standard regulations set by organizations including the Food and Drug Administration (FDA) in the USA and the European Textile Services Association (ETSA) have not specified the use of antimicrobial or other valuable textile properties that could enhance the performance of medical uniforms making them safer for the medical professional and patient.

As was explained above, the clinical uniform market is saturated with a number of wholesale offers largely motivated by profit; thus, production costs are kept to a minimum. Garments in most cases just meet the rudimentary requirements of health care professionals, which is to clothe them. Little design innovation in terms of function and performance has been applied to these garments, particularly doctor's uniforms, despite evidence suggesting that medical uniforms play a role in the spread of deadly bacteria. On a functional level in some cases the uniform physically inhibits the wearer and in essence promotes bad behavior.

Ben Favret is CEO of Vestagen, a company that has developed Vestex® technology, a clinically proven antimicrobial textile for medical uniforms. He explained that studies have shown that the common polyester/cotton cloth used in most medical apparel has been proven to carry and transmit deadly bacteria. In a presentation regarding the new technology he developed, he asked the audience to imagine a doctor walking from patient to patient wearing a contaminated uniform, where a doctor who is actually compliant with hand washing unknowingly carries infectious bacteria on his/her clothes, spreading contamination as he/she carries out daily rounds. Yet only a small minority of manufacturers offer anti microbial uniforms to the market.[36]

Nat Landau is owner of Landau Uniforms, one of the most recognized medical uniform brands in America. He explained that he introduced an antimicrobial offer into his uniform range but found the technology did not perform consistently during testing and ultimately it proved too risky for him to promote in case of a lawsuit. He considered continuing to use the antimicrobial fabric without promotion but this also proved impractical, as he could not justify the additional cost of the garments to the purchasing companies. As a result, he stopped using the antimicrobial fabric.[37]

Doctor Manal, a psychiatrist at Al Ahli hospital in Doha, explained that she is unhappy with the lab coats provided for her by the hospital. She observed that the fit is not flattering or suitable for her shape, the lab coat sleeves are too long, the shoulders are too wide and she does not like the fabric. To compensate for these deficiencies she hires a professional tailor to custom make her lab coats, which are specially tailored to fit her.[38] She is not the only doctor in Qatar tailoring her own lab coats. In discussion with a local tailor he commented that he has many doctor clients for whom he tailors lab coats. Interestingly, they provide him with the fabric. I asked to see some and was surprised at the discrepancies in quality ranging from poor quality Polyester cotton blends to 100% polyester.[39] None of these fabrics are antimicrobial.

Further investigation with the Head of Nursing at Aspire Hospital in Qatar revealed that uniform pockets are a major source of contamination. He suggested that uniforms should not have pockets. This would prevent the wearer from putting potentially contaminated objects into the pockets and inadvertently cause bacteria to spread. This logical suggestion may support the drive for eliminating textile contamination by removing an area, which is more likely to harbor bacteria due to its use, but how does this solution match with the clinicians' need for pockets?[40]

It is clear that the current medical uniform is not fit for purpose on many levels, including health and safety, practicality and comfort. The research shows that there are better alternatives possible, which could be used in uniforms. However, some of the reasons preventing widespread production and use of these alternatives include cost constraints and limiting standards in policy. These constraints have, in essence, stagnated the development of medical uniforms.

Medical professionals often wear lab coats that are ill fitting and appear shabby on the wearer. On recent hospital visits carrying out observational research I was particularly struck by the appearance of clinician's lab coats. Many professionals wore coats that did not fit properly, were usually oversized with rolled up baggy sleeves, pockets sagged and the collars were crumpled. In the worst cases the fabric had greyish tones from over-use and laundering, although they appeared unhygienic. With this in mind, I realized that both metaphorically and physically one size does not fit all, and one solution will not suit all. Maybe the approach to uniforms should be more bespoke so that each

Figure 34 Professional footballers 1960s

Figure 35 Professional footballers 2013

Figure 36 Cyclists 1950s

Figure 37 Cyclist 2012

Figure 36 Doctor's clothing 1950

Figure 37 Doctor's clothing 2014

Figure 40 A&E, Al Ahli Hospital, March 2014.

Figure 41 Nike speed suit enhances athlete's performance to run faster than running naked

individual has a lab coat that fits perfectly. The system surrounding the uniform with current mass manufacturing techniques, the procurement process, cost implications and logistics cannot seem facilitate this idea for clinical uniform wearers, yet this is possible in other clothing sectors. The trend towards individual service and a bespoke offer is available in many clothing sectors.

The sports wear industry is usually the first to offer new innovation in technical advancements to the consumer. Sportswear brands such as Nike, Addidas, Reebok and Puma invest millions of dollars annually to conduct in-depth research and development into new and innovative technologies, textiles and manufacturing techniques to constantly enhance their products to offer advanced performance unlike the medical wear industry.[41] Nike have developed a side to their business offering consumers the option to customize trainers. The consumer chooses fabrics, colors and styling details when he/she places an order through an online retail store. The product is custom made and delivered within four weeks of placing the order. Advancements in manufacturing capabilities have enabled this to become a reality and digital printing has made it cost effective to produce single items versus the huge costs associated with screen-printing. Shoes are created using engineered knitting techniques that create the upper of the shoe in one piece, thus offering a number of benefits including eliminating the cost of cut and sew, and actually reducing the amount of waste in producing the shoe.[42] This technique offers the ability to change the design very quickly without increasing the production cost. In industrial manufacturing 3D modeling, advancements in materials and additive manufacturing or 3D printing, as it is commonly known, have opened up possibilities for manufacturing in a way not seen since the dramatic change that occurred during the industrial revolution.[43] New manufacturing techniques challenge the traditional methods of mass production, enabling products previously unthought-of to be created and manufactured using the digital modeling skills of engineers and designers. Product development is changing at a rapid pace. Technological advancements and investment are key to its success. The fashion industry on the whole still produces clothing in the traditional industrial revolution manner and hence the advancements in additive manufacturing in clothing are lagging behind other industries. However, given the interest from designers and manufacturers alike, these advancements will penetrate the clothing sector when these advancements become more commercially viable, including reducing the time and cost to create first prototypes.

ANALYSIS

The medical uniform market is saturated with a number of brands that supply uniforms internationally. Lab coats are offered by all brands. There are many styles on offer, each with subtle variations fashion detailing in seaming, collar shape, pockets and styling. However, the base cloths used to make the garments are predominately the same and are composed of blend of polyester and cotton in a basic weave, which conforms to the industry standard regulations set for medical wear. Surprisingly these standards have not specified many valuable properties that could enhance the performance of the garment by making it a safer uniform for the medical professional and patient. The textile used to make the garment can be addressed in a number of ways to add increased function and performance. In terms of aesthetics, there is considerable evidence to support the elimination of long sleeves. This policy was introduced to reduce pathogen cross-transmission by minimizing patient contact with contaminated, infrequently laundered items, but a blanket approach to sleeve length may not be appropriate in all clinical settings, especially in certain parts of the world. In the Middle East, doctors adhering to Islamic dress codes wear long sleeves and it would be culturally unacceptable for them to engage with patients while wearing short sleeves. So even though a decision taken by hospital administrators to create a policy banning long sleeves may seem logical, this policy is likely to be rejected by practitioners and patients in many parts of the world. In my approach, I have examined how can the long sleeved lab coat be maintained yet address some of the problems it causes. Below is a list of criteria that the lab coat textile could and should achieve:

Recommended Fabric Qualities:

- **Crease resistant**
- **Fluid resistant**
- **Soil resistant**
- **Active barrier protective antimicrobial**
- **Stretch**
- **Durable**
- **Breathable with wicking properties**
- **Comfortable**
- **Aesthetically pleasing**
- **Professional looking**
- **Withstands commercial laundering**
- **Non-leaching**
- **Color fast**
- **Class 2 OKEX**
- **Meets international ETSA standards for medical textiles**

Problems with the current market offer:

- **Unisex lab coat is unflattering on female form**
- **Oversized ill-fitting lab coat looks sloppy and unprofessional**
- **Uncomfortable for the wearer**
- **Restrictive ergonomically**
- **Sleeve length too long**
- **Cuff opening too wide**
- **Body length too long**
- **Button fastening not intuitive for female where right over left fastening is preferred**
- **An ill fitting lab coat does not enhance the professional**
- **Problems with placer holder of security tags**
- **Varying fits make it difficult to choose the right size**


HOSPITAL
SYSTEM

HEALTHCARE ASSOCIATED INFECTIONS (HAIs)

The topic of the doctors' clothing has become part of a large debate with conflicting ideas on the appropriate attire for the doctor. HAI's have intensified the debate over doctors' clothing. The impact of HAIs in human and financial terms is severe and measureable. In "Adult Hospital Stays with Infections Due to Medical Care 2007," Jennifer Lucado, et al., indicate that HAIs are a common cause of mortality. In 2002, researchers estimated 1.7 million cases of HAIs in the USA, resulting in 99,000 deaths. The article highlights many of the causes of HAIs, focusing on areas related to bloodstream infections caused by devices, grafts, injections or vaccinations. Following that research, evidence-based guidelines were issued for reducing many types of HAIs.[44] An investigation, by J. A. Wilson et al., examining the significance of uniforms and uniform policy in the prevention and control of HAIs, states that they found no evidence to support the theory of transfer of microorganisms from uniforms to patients in a clinical environment.[45]

However, Sabina Fijan et al., reviews the published literature examining the role hospital textiles play in the spread of HAIs, focusing on the occurrence of microorganisms on hospital textiles. The body of the reports summarized by Fijan, et al focus on hospital linens, concluding that there is clear evidence that linens carry microorganisms which can lead to outbreaks of HAI's. The reports further conclude that the main causes for contamination include improper laundering and handling of laundry.[46] Adding to this evidence, C. Perry et al., in a study examining hospital uniforms, confirm the presence of microorganisms on nurses' uniforms before and after a working shift.[47]

Adding to the above literature, Stacey Butterfield[48] and Betsy McCaughey[49] in separate articles, examine the link between a serious HAI named Clostridium Difficile (C. diff) and medical uniforms. Interestingly, the reports show the relationship between the lack of good practice when laundering and changing uniforms and the spread of the invisible bacteria through the textile. This research highlights the reasons that textiles become contaminated and to address the problem would require a multi facetted approach including changing behavior and policy to offer a solution.

Dr. Thomas Walsh conducted a large-scale, four-month clinical-wearer trial of doctors' scrubs in the Medical College of Virginia, Richmond and found that 80% of doctors working in a Methicillin-resistant Staphylococcus Aureus (MRSA)-contaminated environment have the common and deadly bacteria present on their clothes. Dr. Walsh compared antimicrobial scrubs made with Vestex® antimicrobial technology to regular scrubs with no antimicrobial and confirmed that the uniforms made with the antimicrobial technology had a very significant clinical result proving a 5-log reduction in the quantity of MRSA present on the clinicians' clothes. This result highlights the values of an antimicrobial textile by reducing the amount of contamination present on the textile. Interestingly the study concluded that wearing either type of uniform was not correlated with significant difference in the presence of bacteria on doctors' hands. In addition to the adherence of stringent regulations related to hand hygiene (the most common method of spreading bacteria), Dr. Walsh advocates the use of antimicrobial textiles in medical uniforms.[50]

To repeat, Jennifer Lucado et al., and Sabina Fijan et al., argue that medical equipment and hygiene practices are the predominant factors in HAIs, Perry C. et al., and Stacey Butterfield and Betsy McCaughey emphasize the link between textiles and the transfer of bacteria. The conclusions of these studies are extremely useful because they indicate that many different areas of the problem need to be addressed, including hygiene policies and procedures, medical equipment and medical textiles, including linens and uniforms, to understand the problems and determine solutions. Consequently, it is highly unlikely that just one solution can solve the many problems associated with doctors' attire. Different settings and contexts require different solutions. This is not only reflected in the doctor's uniform but the doctor's manner and surroundings. The patients' psychological well-being is now recognized as an important factor in recovering from illness, therefore the total hospital experience must be considered when taking care of patients. This concept is reflected in modern hospitals where communal spaces, colors, pattern, interiors and aesthetic of the surroundings are specifically designed as an integral component to support patients.

DESIGN PROCESS

User-centered design, participatory design and contextual design are terms that have been used as descriptions of a process that integrates the product user into the design process. Each approach holds as the role of the user as central. It is imperative to understand the needs and wants of the user when designing the product. This user-centric method of designing developed in line with advancements in IT where user-friendly interactive platforms were central to the functionality of the product. If the user could not use or navigate an interface then it was useless. This process has evolved to encompass many design disciplines; however, it is costly and time-consuming to conduct and evaluate research in this way. Where this process has found success is highly specialized clothing sectors including sports and clothing for dangerous activities. Examples include Formula One racecar drivers, fire fighters, military uniforms and space research. In the general clothing market, user research is usually limited to customer focus groups and carried out post product development to assess the likelihood of the garments being purchased by the consumer. Criteria for assessment are based on personal preference, aesthetic and price. In the case of uniforms, the customer in often an administrative body or procurement department unrelated to the user and the purchasing criteria in this case is most often based on the bottom line cost to the institution.

Of significance to the current research is that medical uniform design typically lacks the user's input. Sidra Hospital has now appointed a number of clinical leadership teams and I obtained an interview with Dr. Guy Brisseau, the clinical chief of Pediatrics.[51] Dr. Brisseau is a pediatric doctor at the top of his profession and our discussion confirmed most of the information I gained through secondary research. I met with Dr. Brisseau on the executive floor of their administration offices because the hospital is currently under construction. Informed by my background research for this project and my previous experience, I arrived with a set of questions that I had hoped to ask him regarding his preferences and opinions on doctors' uniforms. One of the first things I wanted to understand was his perception of the lab coat and how he felt receiving it when graduating as a doctor. Based on my research I had assumed that he would discuss is as a moment of pride and recognition of entering the medical profession, but in fact he explained that he graduated in Canada where the WCC is not common, and that the white coat for him meant very little. He said that receiving his beeper meant something far more significant to him and wholly represented the responsibility he now had of being a doctor on call. Dr. Brisseau explained that he rarely wore the lab coat at this stage in his career and limited its use to the operating areas of the hospital, where he wears it to cover his scrubs and keep them from being spattered in blood during operations. He explained that the lab coat was a visible sign of a hierarchy that is in naturally inherent in the medical profession explaining, "patient care by committee does not work." Where there is a life and death situation, it is the most senior physician who must make the decision, and the "buck drops with him." However, Dr Brisseau maintained that he felt the white coat could also act as a barrier in communicating because of the symbolic hierarchy it represents and that he did not want to create barriers when communicating to his staff or patients. Dr Brisseau also explained that patient care is the most important part of his job, and being able to communicate in a way that does not overwhelm the patient requires skills to be able to simplify information in an understandable, unintimidating and acceptable way.

I mentioned how research demonstrates clothing can have an effect on cognitive ability and posed the question, what if a doctor's clothing could improve their cognitive ability? Dr. Brisseau paused and remarked that the WCC could have this impact on a newly qualified doctor with little experience by helping them to look, and subsequently feel, like a doctor. He suggested it is possible this process could support the new physician in carrying out her or his duties as a doctor. Dr. Brisseau's comments offer anecdotal support for the literature, which indicated that the most senior doctors did not wear a lab coat because, after having worked in the profession so long they do not feel the need for a uniform to symbolize their role as a doctor to themselves or others. In addition to Dr. Brisseau's perception of the lab coat, I also wanted to discuss some of the more tangible aspects of the clothing including questions regarding the textiles role in transfer of infection. From here ensued a lively discussion regarding the topic.

The extent to which textiles play a role in the spread of HAIs is not fully understood, but there is considerable evidence to show textiles are a part of the cross-contamination process. In our discussion, Dr. Brisseau explained that unless the research clearly indicated an actual **patient benefit** he would not consider making a decision to adopt antimicrobial textiles in hospital uniforms. He explained that for the research to be accepted by clinicians, they require scientific proof under the medical **Gold Standard with a randomized double blind study,** which is the most rigorous form of testing and used by the pharmaceutical industry when

approving drugs to counteract possibilities for bias in testing. Even then, if the anti microbial reduced the level bacteria present on the textile, Dr. Brisseau suggested that the medical world has super bugs that are resistant to antibiotics and that there may be the possibility that by eliminating the other forms of bacteria, in fact you are creating a prime substrate for the super bugs to survive. We also discussed the hand washing exercise, which is recognized by many as the most important exercise in sanitation. Dr. Brisseau explained even in clinical trials, where doctors know they are being studied, only 85% of the doctors adhere to the exercise. When asked why, he explained that according to the standards necessary, it takes three minutes to wash hands properly to clean hands effectively and in the case of a doctor who sees 60 patients daily that is equal to three hours of hand washing in the day. Physicians are far too busy to be able to allocate three hours each day to hand washing. We also discussed whether there was an alternative way to sterilize hands that would take less time? Dr. Brisseau suggested UV light as a possible option. Currently sterilization devices and products harnessing the power of UV light are used in hospitals to sterilize medical equipment thus preventing the spread of bacteria. If the UV light could prove a viable option to replace hand washing, it would eliminate a number of hindrances to doctors such as reducing the time needed to sanitize their hands, eliminate the need for water and eliminate the need for physicians to roll up sleeves, and thereby contaminating the sleeves of the lab coat. This was my first experience of interdisciplinary design thinking with a doctor.

In discussion with Doctor David Sigalet, Clinical Chief of Surgery at Sidra hospital, he mentioned that even though hand washing is the primary method of sterilizing the hands, the long sleeves of most lab coats require physicians to roll up the sleeves before they can wash their hands, thus transferring bacteria and other potentially harmful contaminants from the physician's pre-washed hands to the sleeves of the lab coat. These contaminants remain on the coat after the hands are washed and increase the possibility of infection for anyone who comes into subsequent contact with the physician's coat until it is decontaminated in the laundry. Doctor Sigalet suggested that all lab coats should have short sleeves[52] as a way to address this problem. This recommendation ostensibly represents a straightforward solution, an easy fix, but it may also be a superficial fix. Design thinking emphasizes comprehensive and holistic analyses of problems in order to develop optimal solutions. Short-sleeved physician coats may help prevent contamination but, as a designer, I believe it is important to conduct deeper-level analyses to ensure we are not just accepting the first idea that comes to mind and in so doing, miss out on better solutions that could be determined through deeper ideation and more innovative approaches.

I also interviewed Dr Deepak Kaura, the Chair of Radiology at Sidra Medical and Research Center (Sidra). Dr. Kaura was passionate about the topic and had taken a personal interest in the decision-making regarding uniforms for the Sidra staff.[53] During our meeting I showed Dr. Kaura some of the designs developed for Sidra hospital. Reviewing some of the designs together we began to discuss some design features in detail, specifically focusing on the nurses' uniforms. Dr. Kaura immediately pointed out that a concealed fastening, a feature designed to hide buttons, would not be suitable for this type of uniform. I was surprised and asked him to elaborate. He explained that if a nurse opened the button with blood on her fingers the blood would get trapped in the fabric fold, contaminating the fabric and that this design feature made it difficult to launder and sterilize. I immediately expressed that this was exactly the type of information we needed at the design development stage of the project that an insight like that would influence design decisions. He was surprised that we had not talked to the clinical team as part of the design process; however, as has been discussed above, hospital procurement team often manages the decision over uniforms and the main priorities of the purchasing team and very different from the concerns of the user.

Dr. Kaura's insights highlighted once again how important it is to understand user needs in order to gain an intimate knowledge on the subject matter. I explained to both doctors that I intended to carry out further research and design development on doctors' uniforms and asked if they would like to participate in the research and design process both responded with a resounding yes.

ENCLOTHED AND COGNITION

It has been established that a medical uniform acts on many levels. It provides the wearer with an aesthetic that symbolizes inclusion in a specific social group, often the hierarchical position of the wearer within that group, and is simultaneously a piece of clothing that protects the wearer. We have also seen that the multi-billion dollar clothing industry is constantly evolving as some sectors develop and incorporate advancements in technology to enhance clothing performance. This is particularly evident in specialist areas for extreme environments and situations, including the military, fire fighters, space travel and sportswear. These sectors apply new technologies to develop and advance materials and garment construction, developing new methods of production to create performance clothing. Martin Lotti, Nike's global creative director for the 2012 Olympics, explains how Nike design and engineer sports performance wear place psychology on an equal footing with technological advances when designing sportswear to improve an athlete's performance.

Underlining the significance of style for results, Lotti reported that Alpine skier Maria Kirkova once told him, "I perform better if I look better." This brings me to question whether a better-looking uniform might also enhance a physician's performance?[54] Hajo Adam and Adam Galinsky of Northwestern University carried out a study to examine the effect of clothing on cognitive ability. Their research confirmed that when the participants wore a doctor's lab coat they performed significantly better in cognitive tasks than they did when wearing other clothing. In the same study the group was split, both groups were given white lab coats; however, half the group was told it was a painter's coat and half the group was told it was a doctor's coat. The volunteers who wore a "doctor's coat performed better on sustained attention tasks and were better able to discriminate features in nearly similar pages, then those who wore a painter's coat."[55] Joshua Davis of Barnard College noted these investigations suggest, "clothing's symbolic meaning as visual communication, can influence the viewers attributions and the wearer's behavioral alignment with the role suggested by clothing." Galinsky also conducted tests to evaluate the difference between seeing a doctor's white coat and wearing it.

The group wearing the coat showed the greatest improvement in performance. Dr Galinsky explained, "you have to wear the coat, see it on your body and feel it on your skin for it to influence your psychological processes. Clothes invade the brain, putting the wearer into a different psychological state."[56] It is clear that clothing can affect the wearer as much as the viewer in terms of the doctor-patient relationship. Therefore, if the doctor feels he/she looks more like a doctor, will he/she perform better in the same way an athlete can perform better when he/she feels and looks good and confident in their athletic apparel? Thinking again of Dr. Brisseau's comments regarding student doctors' confidence wearing a lab coat, the evidence strongly indicates that the lab coat has a very important role to play within the medical world and to society at large, functioning as a tool on many levels, including enhancing the behavior of the doctor and acting as a signifier to the patient and to society.


DESIGN

DESIGN

To realize the applied outcome of my research I investigated numerous design methodologies before adopting speculative design. Speculative design is an innovative method of design practice described by Dunne and Raby as a method that aims to open up new discussion about existing situations. This method can be used to address wicked problems by creating a space to discuss and debate alternative ways of being.[57] To truly understand the lab coat I have taken a holistic view of the world in which the product exists in, even though much of the data I have uncovered reveal limitations at every turn which prevent the lab coat from reaching its potential as a better performing, safer and more valuable product. As part of the process I used science fiction prototyping, future scenario building, or future narrative scenarios, all names described to imagine and envision the future in a new way.[58] This form of prototyping allows the creator to imagine a future reality based on real science and technology by looking at emerging patterns and trends and using them to create a fictional story that has fictional creations embedded in the story. Using the specific method of narrative scenarios I created a fictional story involving characters, in this case I talked about doctors and patients living in a hospital environment in the future. The advantage of using a story is that characters can engage in behaviors that highlight key aspects of the scenario.[59] With this story I aim to propose a **What If** product for a **What If** medical care environment. In helping to define the parameters for the products in the scenario I built on problems facing today's hospital and caregivers along with an analysis of the past history of the doctor. Within this narrative I focused specifically upon the doctor's lab coat by creating a list of garment properties addressing some of the problems faced by today's doctors. Solutions to the problems are based on combining emerging technologies, including Nano technology, material science, textile development, communication systems, and IT that will enhance the performance of the doctor's uniform.[60] I also created mood boards to visualize the aesthetic, feel and concepts behind the scenarios.

The concept proposes new enhanced functions of the uniform that will improve the patient doctor relationship by acting as a tool over and beyond the current symbolic and functional qualities of the existing doctor's lab coat. In the future narrative the uniform acts as a tool to aid communication. It becomes a receptor for digital information that can be used by the doctor and shared with the patient enabling the doctor to understand not only the complete medical history of the patient but also aspects of patient's personal life. It is intended to communicate knowledge and provide the medic with a holistic view and understanding of the patient. Access to the information will allow the doctor to efficiently and accurately treat the patient while giving the doctor background knowledge of the patient aiding communication in an empathic manner towards the patient. For the patient, the physician's uniform will act as an information provider. It will detail the doctor's credentials, indicating not only the doctor's name and security details, but also display the doctor's professional background including education, training and experience in the field. All of this is to offer the patient an insight into the doctor, facilitating a situation for a shared knowledge and understanding between doctor and patient and vice versa. The information will be visualized on and through the textile of the garment, which can display data in real time using nanotube carbon fiber and wireless technology.[61] The uniform will have chameleon-like properties, changing pattern and color depending on the patient or situation. White is shown to be the professional choice and the color most understood as a doctor in a clinical setting; however, the fabric can mimic many patterns and change appearance, for example, when talking to a child or the child's parents. Changing from a child friendly pattern to a more conventional white color during consultation with parents. Instant access to current and previous patient records ensure a continuity of care from doctor to doctor no matter which medical professional within the team is attending the patient. The doctor uses the lab coat to help explain complicated procedures in a clear and simplified way to patients using visuals and info graphics. The lab coat offers the ultimate in protection for the doctor and patient using antimicrobial textiles. In addition, the lab coat has embedded sensors that alert the doctor when it becomes contaminated, ensuring the doctor changes into a freshly laundered uniform. The uniform will keep record of the professional's hand sanitation procedure and communicate when it is required or has been forgotten. To address some of the issues of hand sanitization the scenario proposes a new method of sanitization using UV light which eliminates the hindrance long sleeves currently cause and also proposes a solution that uses less of the earths' most precious natural resource.

The lab coat has the ability to display data and records in real time. The information is transmitted wirelessly in an exchange between patient and doctor using individual smart clothing embedded with sensors.[62] The smart technology registers patients' vital signs, eliminating the need for hospital gadgets, which harbor dirt and bacteria. Such gadgets are the cause if the transmission of bacteria.

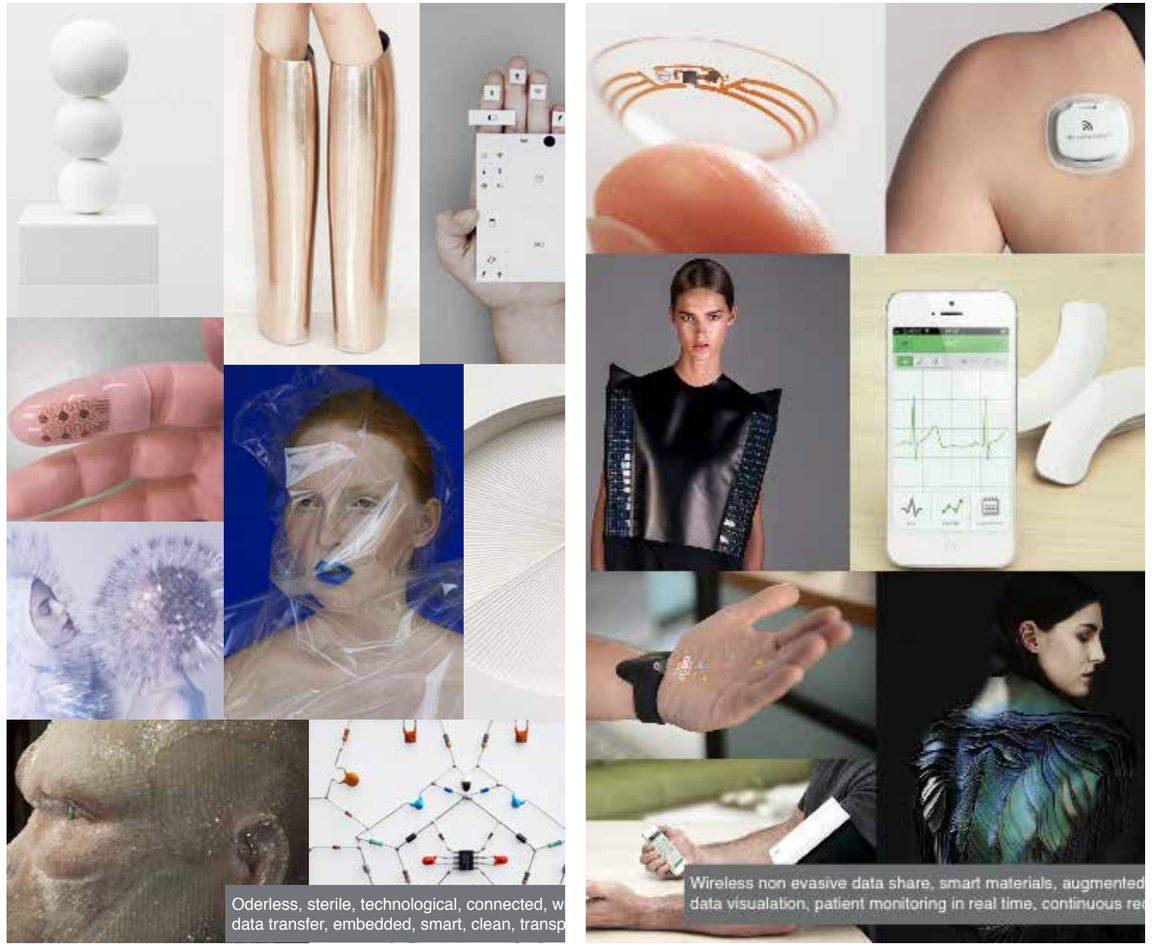


Figure 42 Mood board, technology

Patients' rooms will be more sterile as equipment will not move from room to room, doors will be automatic opening when those authorized to enter are sanitized. All surfaces and textiles used in the patient rooms will be made from easy to clean antimicrobial Nano technologies. Beyond the technical performance of the garment and hospital surroundings, the story also focuses on human behavior. Good design has the ability to positively impact human behavior using engineering, education, communication and monitoring. Research confirms that in many cases HAIs are transmitted through human error such as improper laundering and non-compliance with hygiene policies. In this scenario, the uniform is designed to promote better behavior on the part of the doctor by aiding communication that will enhance the doctor-patient relationship and also prompt the doctor to sanitize hands and change and clean the uniform when contaminated.

FUTURE SCENARIO I: DR. WHO?

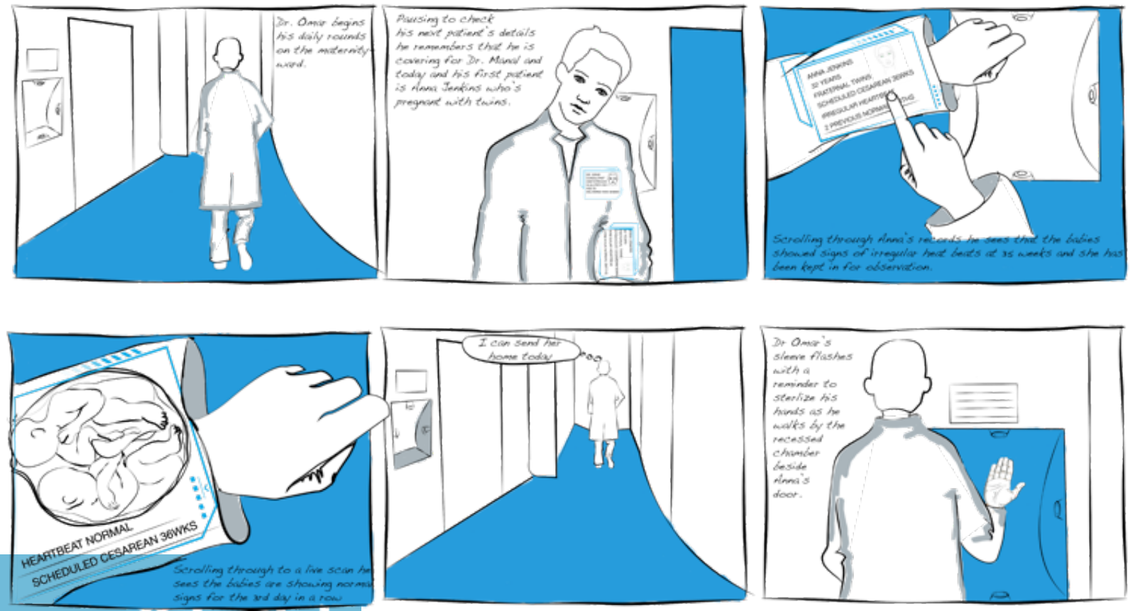
Scene: Doctor on hospital rounds on a maternity ward.

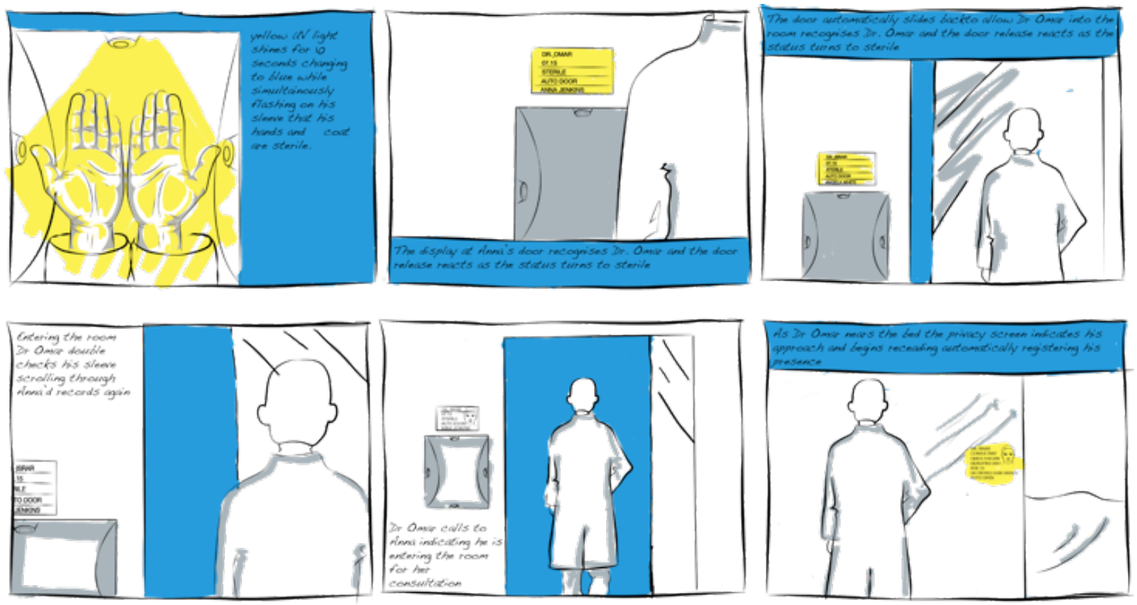
Characters
Doctor – Male Dr. Tarek Omar
Patient – Pregnant Female Anna Jenkins

Dr. Omar arrives at 7.15am, which is his usual time to begin daily rounds, checking on his patients from the night before. Walking by the nurse's station, his sleeve flashes, reminding him that he must visit Anna Jenkins this morning. As he pauses to recall the details of this particular patient – he has over 60 patients to attend daily – Dr. Omar raises his arm to view the textile data display showing Anna's details and photo. These are strong reminders for the physician, serving as a catalyst to jog his memory for even more information. Today he is covering for Dr. Manal and recalls that this patient is 36 weeks pregnant with twins and under observation because the twins' showed signs of irregular heartbeats during week 35 of the pregnancy. Checking the records, Dr. Omar happily observes that the twins' vital signs are normal this morning for the third day in a row.

Still scanning Anna's chart, Dr. Omar sees that this is not her first pregnancy. She has a 5-year-old daughter, who will become big sister to a brother and sister in two weeks' time following a scheduled Caesarean at 08.00 on April 4th, 2034. What an easy birthday it will be to remember.

Still using the information provided on this coat sleeve visuals, Dr. Omar checks Anna's pregnancy history right back to 2029 when her daughter





Alana was born, seeing that she encountered no previous complications in pregnancy. Happily, the doctor will be able to send Anna home today to spend the last week of her pregnancy getting ready to welcome the new arrivals into their family.

Walking down the corridor to room 08A Dr. Omar's sleeve flashes again reminding him to sterilize his hands. He extends his hands into the recessed chamber located to the left of the door, where the yellow UV light automatically fills it; his hands and clothing appear yellow with the reflection of light.

As he waits 10 seconds until the light changes to blue, Dr. Omar is reminded of his early days of being a clinician just out of university, when water was still used to sterilize hands, making it almost impossible to adhere to the three minute protocol to clean hands. How did he ever manage to adhere to it? HAIs (Healthcare Associated Infections) are almost unheard of in a clinical setting nowadays, due to the strict implementation of measures to combat infections, which almost crippled medical care in the early part of his career. These measures have improved medical care expediently by eliminating not only HAIs but also many unnecessary hospital visits and stays through the use automated functions, touch-free surfaces, wireless data, tool-free procedures, and virtual care. Now only critical cases enter hospitals.

The blue light indicates that his hands and sleeves are sterile and the door opens automatically, allowing Dr. Omar into the patient's room.

As he walks forward and toward the bed, Dr. Omar greets Anna. The doctor explains the purpose of his visit today as the privacy panel automatically recedes into the wall. Anna is lying with the sheet covering her protruding belly.

This is the first time for Anna to meet Dr. Omar, who is covering for her regular consultant. The doctor asks Anna how she is feeling this morning. Anna squints as the reads the digital display of data on Dr. Omar's chest. With relief she sees that Dr. Omar is a very experienced physician, having studied and worked internationally. Anna also notes that Dr. Omar is affiliated with a prestigious institution and is a specialist in the treatment of multiple fetus pregnancies, having delivered over 5000 babies during his career.

Dr. Omar glides his hand over the infrared panel to activate the live digital display of Anna's scan, which appears instantaneously on the shimmering textile surface of the bed sheet, thanks to the CMOS

sensor with its ability to send 3D images of the womb in real time to the data display. The babies bob up and down, totally unaware of this observation. It still makes Dr. Omar smile when he sees the look on a patient's face as they watch the miracle of life.

Dr. Omar discusses the twins, pointing to each child's heart, remarking on the normal heartbeat and explaining that everything looks good.

Anna's face relaxes with relief as she hears the news. Dr. Omar asks Anna if Isabelle her daughter is looking forward to having a new brother and sister to look after.

Anna smiles thinking what a change it is going to be for her family.

FUTURE SCENARIO II: DR. WHO?

Scene: Doctor on hospital rounds on a pediatric ward.

Characters
Doctor – Female Dr Jane Israr
Patient – 12 year old boy Mustafa

Dr. Israr, preoccupied by an emergency case she attended earlier, starts her rounds. The soft light display at the nurses' station reception gently fills the space as it reflects on the clean surfaces. She stops and raises her arm to look at the digital display on her sleeve. As it comes into focus, she smiles, seeing the details of her next patient, Mustafa. The young boy's ankle had been fractured in a fall. The surgery was complicated and lasted 2 hours longer than anticipated. Dr. Israr looks at the date – March 25th 2034 – and thinks how time flies as she notices the surgery was carried out 10 days ago.

Scrolling back through Mustafa's records she notices that Mustafa was a premature baby who remained in intensive care for 3 weeks post birth but since that time has developed normally with no complications. The test results indicate that everything is clear and she anticipates that he will be sending him home today, after one final observation.

As she walks down the corridor to the examination room, she notices that Mustafa has a Labrador dog at home – that will be a good talking point.

The data flashes, reminding her to sterilize her hands. Raising them, she inserts them into the recessed chamber. At once, the light beams a yellow hue before turning blue, indicating that her hands and uniform are sterile. Then her uniform changes color from white to a yellow gradient, which is deemed less intimidating to children. The examination-room door opens automatically where Dr. Israr enters to see Mustafa sitting upright, looking sad.

Dr. Israr walks towards her patient and sits opposite him and at eye level. She begins the conversation by asking how he is feeling. Mustafa explains that he is feeling much better. The doctor swipes her hand over his sleeve and the live scan of the boy's bone appears on the surface of the textile of the exam gown. Both observe the display. Mustafa is an inquisitive 12 year old, who is not shy about asking questions. In response to his queries, Dr. Israr taps her chest and reveals an animated data display of the bone repair while explaining the details to the child. Mustafa is fascinated as he watches the animation and asks more questions. A picture speaks a thousand words, thinks Dr. Israr, marveling not for the first time at how true the phrase is.

She tells Mustafa that he will be discharged today and asks if he is excited about seeing his dog again, telling him she also has a Labrador named Goldie and asking the name of his dog?

BACKGROUND TO THE NARRATIVE

HAI's

In an effort to eliminate HAIs, the hospital has ensured that surfaces are flat, so that there are no nooks and crannies in which dirt can lodge, and are easy to clean.

Everything is automated to avoid the need for anyone to touch surfaces.

Hand washing with water has been replaced with UV light to kill bacteria, which also eliminates problems with long sleeves as it sterilizes the cloth too.

All medical equipment is contained in each patient's room nothing moves from one room to another.

Antimicrobial intelligent textiles are used in the uniform. If contamination occurs, the thread on the fabric surface changes color and the data display indicates contamination.

Doctors don't carry tools, as the lab coat replaces all the traditional tools needed by a doctor. The coat functions on a totally new level.

The stethoscope is replaced with patient sensors that provide continuous real-time data of the patient's vital signs and wirelessly transfer the information to the doctor's digital display.

Communication

All data is accessed through digital displays that are either embedded in smart materials or by augmented reality projected on to surfaces within the room.

The textile of the uniform digitally displays patients' data and records.

The textile surface can change appearance in color and pattern when necessary depending on the circumstances of the interaction.

The lab coat also functions as an information provider for the patient, by displaying the doctor's credentials and data relating to their health issues.

The bleeper is replaced by the digital signal on the doctor's uniform.

Via the uniform's digital display, the doctor replaces the traditional clipboard of patients' records with digital records. The entire history of the patient can be accessed in one location.

The medical staff badge is replaced with the digital display on the doctor's chest. This shows not only a name and staff number, but also the credentials of the doctor's training, experience and success.

DESIGN INNOVATION

Figure 43 Lab coat toile, calico fabric

Figure 44 Lab coat toile, calico fabric

The lab coat in the narratives is based on emerging technological advancements not currently commercially available in the market. However I decided to create a physical prototype to create an aesthetic representation of the design. Using garment technology this design addresses some issues relating to problems identified in the research. Going back to my roots I followed the classic fashion design process researching the most up to date trends in fabrics, textile technology, color, retail and reviewing the latest catwalk collections from London, New York, Milan and Paris. I collated the research into storyboards visualizing inspiration for styling, silhouettes, details, fabrics and trims. These combined with the research and list of criteria previously defined **(reference page 42)**. I began the iterative process of designing the lab coat by sketching shapes, silhouettes, accessories, construction details and then draping muslin fabric on a mannequin to create 3D forms of the 2D sketches. When I was happy with the shapes I converted these to paper patterns, which were then used to make physical prototypes. The concept design was modified with each new sketch and prototype. The result is a design engineered to accommodate existing production

Figure 45 Lab coat toile, calico fabric

Figure 47 Lab coat toile, calico fabric

Figure 46 Lab coat toile, calico fabric

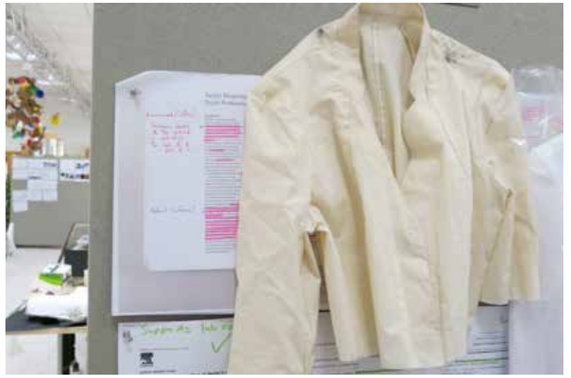


Figure 48 Lab coat toile, calico fabric

capabilities of clothing manufacturers while utilizing some tried and tested construction techniques used by sportswear and other clothing sectors.

The designed outcome includes streamlined male and female lab coats that have eliminated potentially problematic styling details to reduce contamination touch points including buttons, pockets, flaps, fabric folds, raw edge seams. The garment has minimal paneling also reducing the number of areas to harbor contamination. The design acknowledges the symbolism of the traditional lab coat maintaining an understandable professional look by using garment engineering to create a design that is familiar yet new. The design also has an added elastic detail in the sleeve that helps to keep the sleeve up when hand washing. The final prototypes were made using a local tailor who regularly makes lab coats for a number of doctors he has as customers.

EXHIBITION

Figure 49 Video still

The main challenge of the thesis exhibition was how to communicate a lot of research in a static show, which could engage a live audience in a short amount of time. This required dissecting the research into understandable bites of information to be displayed in a setting complementing the research. To do this I focused on a number of key aspects to highlight.

- **Future scenario and narrative of the world and the artifact**
- **Performance and function of the new lab coat**
- **Prototypes**
- **Problems within the healthcare system**

The exhibition space was carefully curated to represent a doctor's examination room. I sourced old medical furniture, bed linen and a number of additional paraphernalia from the medical world to create an installation of a doctor's examination room. Posters commonly used to communicate information in a doctor's office were hung on the walls highlighting key aspects of the research. The installation was designed to create a setting that would enhance the exhibition experience by engaging the audience full senses, literally drawing them into the smell, sound and look of medical world.

Figure 50 Video still

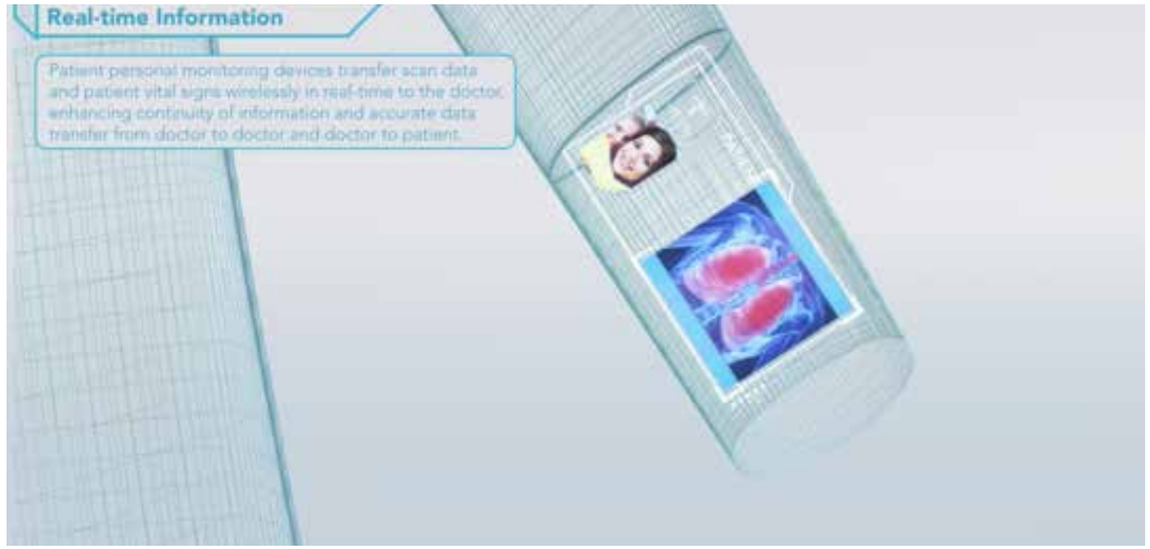


Figure 51 Video still

Figure 52 Dr. Consunji reading comic strip scenario

Figure 53 Dr. Consunji viewing the exhibition

To communicate the narrative I created a visual in the form of sequential art, which illustrates the story in a simple and explanatory manner. The artwork is also used to create a pamphlet in classic medical style to hand out during the thesis exhibition. The brochure adopts a comic book style illustrating the characters through which the artifact comes alive. The graphics are designed to be informative and provide context to the story in an understandable way

emphasizing the behaviors of the doctor in the new world. To illustrate the lab coat of the future I utilized video, animation and 3 D modeling to virtually create a prototype. The video highlights the lab coat design features promoting the benefits of the new design.

Figure 54-57 Exhibition installation

Figure 58 Exhibition Opening with Dean Allyson Vanstone

Figure 59 Exhibition opening with Dr Rafael J. Consunji, Director HMC Injury Prevention Program

CONCLUSION

Research indicates that the lab coat, a seemingly simple garment, is actually embedded in highly complex social and professional systems that have shaped the resulting product. To change the lab coat requires a multi-facetted approach through many channels including the user, the patient, professional colleagues, society, the producer and the hospital bureaucracy. This requires changes in policy, protocol, testing, standards, specifications, manufacturing, laundering, purchasing and budgets before a new design could be adopted, and even then for these changes to be accepted the concepts would require effective communication to consumer and society. Change is difficult to accept and therefore changing the lab coat radically and in the short term is not feasible. However, it would be achievable through an interdisciplinary approach, engaging all the above-mentioned stakeholders, communicating the possibilities, justifying the costs and quantifying the benefits for change. In addition, education and awareness programs would be necessary to communicate the change and secure the buy-in from all stakeholders by targeting audiences within the medical profession and patient audience by promoting the benefits of the changes. Many medical professionals have stopped wearing the white coat for various reasons including personal preference, perceived symbolism, associated perception with hygiene, physical garment limitations and hospital cutbacks. But not wearing the lab coat has also left a void where the product is still necessary. This thesis presents a concept for doctors' clothing that builds on the age-old tradition of lab coat with its positive associated meanings and attributes by proposing an alternative that can add value for the doctor and the patient while promoting positive behaviors in the doctor, enhancing the doctor patient relationship and limiting the spread of HAIs.

"The doctor-patient relationship has been and remains a key stone of care: the medium in which the data are gathered, diagnoses and plans are made, compliance is accomplished, and healing, patient activation and support are provided" [63]

Figure 60 Patricia Duignan wearing lab coat prototype

Figure 61 Vestex® technology, polyester/cotton, antimicrobial, medical textile.

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TABLES OF FIGURES

Fig. 36 Cyclists 1950s http://www.wilsoncycles.co.uk

Fig. 37 Cyclist 2012, http://static.guim.co.uk

Fig. 38 Vintage doctor 1950's, www. masterfile.com

Fig. 39 Modern Doctor 2012, www.medelita.com

Fig 40 Clinician attending a patient at Al Ahli Hospital, Doha, Qatar, March 2014

Fig. 41 Nike speed suit enhances athlete's performance to run faster than running naked, http://www.dezeen.com

Fig 42 Mood board, technology, 2013

Fig 43 Lab coat toile, calico fabric, Feb 2014

Fig. 44 Lab coat toile, calico fabric, Feb 2014

Fig. 45 Lab coat toile, calico fabric, Feb 2014

Fig. 46 Lab coat toile, calico fabric, Feb 2014

Fig. 47 Lab coat toile, calico fabric, Feb 2014

Fig. 48 Lab coat toile, calico fabric, Feb 2014

Fig. 49 Still image, lab coat video, 3D Max, Nov 2014.

Fig. 50 Still image, lab coat video, 3D Max, Nov 2014.

Fig. 51 Still image, lab coat video, 3D Max, Nov 2014.

Fig. 52 Dr. Consunji reading comic strip for Dr. Who?

Fig. 53 Dr. Consunji viewing Dr. Who? exhibition

Fig. 54 MFA Exhibition installation, "Dr. Who", VCUQatar, Dec. 2014.

Fig. 55 MFA Exhibition installation, "Dr. Who", VCUQatar, Dec. 2014

Fig. 56 MFA Exhibition installation, "Dr. Who", VCUQatar, Dec. 2014

Fig. 57 MFA Exhibition installation, "Dr. Who", VCUQatar, Dec. 2014

Fig. 58 Dean Allyson Vanstone, MFA Exhibition installation opening, "Dr. Who", VCUQatar, Dec. 2014

Fig. 59 Dr Rafael J. Consunji, Director HMC Injury Prevention Program MFA Exhibition installation opening, "Dr. Who", VCUQatar, Dec. 2014

Fig. 60 Patricia Duignan wearing lab coat prototype, Mar. 2015.

Fig. 61 Vestex® technology, polyester/cotton, antimicrobial, medical textile, Mar. 2015.

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i ACRONYMS AND ABBREVIATIONS

BBE	Bare Below the Elbow
HMC	Hamad Medical Corporation
MRSA	Methicillin-Resistant Staphylococcus Aureus

ii DEFINITION OF TERMS

Doctor – is used when referring to a medical doctor

HAI's – Hospital Acquired Infections, serious life threatening infections acquired during hospital stays one of the biggest problems facing medical care.

Mind Map - Designers use mind maps to reduce information into key words and images by creating a visual structure, which shows the big picture of the information.

Log Reduction – scientific notation to calculate microorganisms, 5 log is = 99.999% reduction.