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

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DR. WHO?
The Science and Culture of Medical Wear Design

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

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Fine Arts at Virginia Commonwealth University

by
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Thank you to all the wonderful people who helped me along this path.
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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 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.

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 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.
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. 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. 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. 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 physicians’ neckties are worn repeatedly and rarely cleaned; making them the perfect substrate to carry bacteria from patient to patient. In addition, long sleeves were deemed a hindrance to the vital exercise of hand washing. 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. Format attire has been shown to instill greater confidence and trust in doctors wear can influence a patient’s perception of the clinician, 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. Format attire has been shown to instill greater confidence and trust in doctors wear can influence a patient’s perception of the clinician, thus, the patients’ confidence in the doctor may be undermined.

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 exploration and development. The studies indicate that the main reasons for this change included infection risk, discomfort, and interference in the physician-patient relationship. In 1991-1994 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 25% of the study population actually wore the white lab coat (92% 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.5 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.6 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.

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. 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 evaluated 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.

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

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

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
DESIGN
PROCESS
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. 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. 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.” 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.” 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 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 a garment to protect the wearer from various forms of dirt and bodily fluids encountered during certain procedures. 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. 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.
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 Yyelland, sociologist and Assistant Professor at VCU Qatar, 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. 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. Blumohagin and others have identified cultural symbols as a form of communication, analogues to spoken words in a natural language. 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...
clique or a larger society. As such, symbols express and reaffirm the fundamental belief systems of that group. 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.

Dr. Ygiland 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. 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?

“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

Bay Scouts)” 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. 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. 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.

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.” 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.” 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 physician to observe, touch, and even cut into the patient’s physical self, all of which are intensely intimate acts. 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 upon the appearance of their doctor. It has been shown that patients actually felt more relaxed when they perceived the doctor to have the same age, height, and weight as themselves. A study published in the Journal of General Internal Medicine found that patients rated doctors who wore white coats as more competent and trustworthy than doctors who did not wear white coats. A similar study published in the Journal of the American Medical Association found that patients who perceived their doctor’s attire to be professional were more likely to feel confident in their doctor’s ability to provide good care.

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.
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:

- No Instruction
- No Discussion
- No Demonstration
- No Familiarity
- No Prior Knowledge
- No Repetition
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 19-20. 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.

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 feelings 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?
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 coat 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. Aesthetically, the silhouette of the garment is similar to the classic tailored, men’s blazer or overcoat. The shape of the coat is a reverse 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 fitter 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 pocket placed on the left hand side as worn, which serves as a pleats and or a hospital identification badge required by all medical staff. This badge is a source of contamination 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 large 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 section of the coat. 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 gardens 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 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.

The classical construction pattern 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 fitter and less flattering on a female shape. This exaggerates the ill fitting appearance which in turns looks untidy and unflattering. 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 fitter and less flattering on a female shape. This exaggerates the ill fitting appearance which in turns looks untidy and unflattering.

Quality assurance checks happen periodically throughout the production process. The garment is finished, pressed and packed. 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.

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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 collected 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 collars, trim, 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.
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 predominantly 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, tapes, technological looking fabrics and quilting. These details were consistent, indicating the likelihood of consistent themes within garments for physicians.
INVESTIGATION IV

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.

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.
Main Themes:

- Professional
- Athletic
- Technological
- Strength
- Powerful
- Authoritative
- Casual
- Rank
- Sterile

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. In a functional level in some cases the uniform physically inhibits the wearer and in essence promotes bad behavior.

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.

Doctor Manel, a psychiatrist at Al Ahi hospital in Doha, explained that the fabric was unhygienic. 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 blends to 100% polyester. 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?

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.
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 trend towards individual service and a bespoke offer is available in many clothing sectors. The system surrounding the uniform with current mass manufacturing techniques, the procurement process, cost implications and logistics cannot seem to facilitate this idea for clinical uniform wearers, yet this is possible in other clothing sectors. 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
- Breathable with wicking properties
- Comfortable
- Aesthetically pleasing
- Professional looking
- Withstands commercial laundering
- Non-leaching
- Color fast
- Meets international ENISO standards for medical textiles

**Problems with the current market offer:**

- Unisex lab coat is unfaltering 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

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 in detailing in seams, 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:

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An ill-fitting lab coat does not enhance the professional appearance of the wearer and can be unflattering on female form. Varying fits make it difficult to choose the right size.
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. HAIs have various causes, which include the use of hospital uniforms. The impact of HAIs in human and financial terms is severe and measurable. In “Adult Hospital Stays with Infections Due to Methicillin-resistant Staphylococcus Aureus (MRSA)”, commonly 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 significant clinical result proving a 5-log reduction in the quantity of MRSA present on the clinicians’ clothes. This result highlights the value of antimicrobial textiles in medical uniforms. 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.

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 patient’s psychoat biblical wellbeing is being increasingly 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, interi or and aesthetic of the surroundings are specifically designed as an integral component to support patients.

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User-centered design, participating 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 value of the user as central. It is imperative to understand the needs and wants of a healthcare provider when designing the product. This user-centric method of designing healthcare products and equipment is the most successful in healthcare, where user-friendly interactive platforms were central to the functionality of the product. It assumed that if the user is satisfied with the product, it is functional. 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.

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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. Merlin Lotti, Nike's global creative director for the 2012 Olympics, explains how Nike design and engineering 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 Kiskova 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 performance79. 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 would 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.”

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 good about how he or she looks, will the doctor perform better the same way an athlete can perform better when he or she looks good? How do the doctors fashion their attire? Thinking again of Dr. Brisseau’s comments regarding student doctors’ confidence wearing a lab coat, the evidence strongly indicates that the choice of garment plays a role in 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.

ENCLOSED AND COGNITION

approving drugs to counterpoint possibilities for taxis in testing. Even then, if the anti-microbiol reduced the level bacteria present on the textile, Dr. Bissessar suggested that the medical world has super bugs that are resistant to antibiotics and that there may be the possibility by existing drug resistance to other forms of bacteria, in fact you are creating another substrate for the super bugs to survive. We also discussed the hand washing exercise, which is recognized by many as the most important intervention in sanitation. Dr. Bissessar 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, if they take 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. Bissessar 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 contaminate the sleeves of the lab coat. This was my first experience of interdisciplinary design thinking with a doctor. In discussion with Doctor David Siglet, Clinical Chief of Surgery at Sidra hospital, he mentioned that even though hand washing is the primary method of sanitizing 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 their lab coat. These contaminants remain on the coat even after the hands are washed and increase the possibility of infection for anyone who comes into contact with the physician’s coat until it is decontaminated in the laundry. Doctor Siglet suggested that all lab coats should have short sleeves37 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. 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, as it was suggested 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 might help that would influence design decisions. Dr. Kaura saw the advantage of being able to simulate and asked if they would like to participate in the research and design process both responded with a resounding yes.

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.

In conclusion, this design project has allowed me to work closely with industry leaders from my host institution and the local medical community. It has given me insight into the purchasing process both at the hospital and at the national level. It has also allowed me to experience and witness first hand the impact that the design of uniforms has on the user and on the medical community. It has allowed me to explore the impact that design can have on the medical field and provided me with a unique opportunity to learn and experience the challenges that designers face when working with professionals in the medical field.
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. To truly understand the lab coat I have taken a holistic view of the world in which the product exists, explored 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. 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 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 is 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. 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 tell a communication story of the diagnosis 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 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, all relevant 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 shared and used by the textile of the garment, which can display data in real time using nanotube carbon fiber and wireless technology. 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 parent. 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 sanitation 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 earth's 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 real time can be visualized and embedded with sensors. 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.

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 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 cool 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 expeditiously 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.

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.

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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 HAI’s, 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

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 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.
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.
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, I utilized video, animation, and 3D modeling to virtually create a prototype. The video highlights the lab coat design features promoting the benefits of the new design.
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-faceted 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.”

Figure 60: Patricia Duignan wearing lab coat prototype

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

Figure 62: Water-repellent technology, polyester/cotton, antimicrobial, medical textile
51 Brisseau, MD, Guy. Chief of Pediatrics, Sidra Medical and Research Center, Doha, Qatar, interview, December 2013.
52 Sigalet, Lyle, MD. Clinical Chief of Surgery, Sidra Medical and Research Center, Doha Qatar. Meeting, March 2012.
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Fig. 1 “Stakeholders Mind Map” pencil on paper, 2014.
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Surgery carried Dr. Samuel out by doctors in black layman’s clothes, 1875.
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Fig. 4 “Trust” Mind map, pen on paper, 2014.
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Fig. 6 Patrick Dempsey, TV series Greys Anatomy, http://media.melty.fr
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i ACRONYMS AND ABBREVIATIONS

BBE  Bare Below the Elbow

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.

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.