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Many People Are Afraid of White Coats. They Should Be

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MANY PEOPLE ARE AFRAID OF WHITE COATS.
THEY SHOULD BE

by

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Abstract

The concept of "do no harm" is not a figure of speech. It is a pledge to our patients to insert ourselves between them and anything that can harm them physically or emotionally. "Do lab coats harbor microbes that are detrimental to our clients' health?" was the question that drove this systematic review. Using a search to cover articles regarding the microbial integrity of the coat, several studies were found to include culture and sensitivity reports along with participants' surveys that increase the data to include demographics, handling habits of the coat along with laundering habits of the owners of the coats. Eight studies were reviewed, seven of the eight did provide survey information, to extract data and conclusions for the summarization of the integrity of the coat. The microbial compromise of the garment was confirmed, and solutions were uncovered as the eight studies were examined. All studies referred to the garment as a source or a potential source of cross-contamination. Using education guided by a multidisciplinary team, nurse practitioners can lead an effective approach to aid in the safe handling of the white coat. Standards for the handling of the coat along with monitoring of the compliance of healthcare workers can lead to a safer environment and better patient outcomes.

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Background/Statement of the Problem

The World Health Organization (WHO) defines a healthcare-associated infection (HAI) as an infection occurring in a patient in the hospital or other healthcare facility in whom the infection was not present or incubating at the time of admission (2017). Healthcare-associated infection was previously defined by the WHO as an infection acquired by the patient while receiving healthcare (2011). In this report, burden of the added cost of a HAI was examined along with the epidemiology of the problem. Countries were divided based on whether they were “high-economic” verses “middle-low” economic in status. The United States of America (USA) had a rate of 4.5%, while the overall rating of “high economy” and other nations with the “high” rating designation, including Europe, had a rate of 7.6%. The “low-middle economy” nations collectively were reported to have a 19.1% occurrence rate of HAI (WHO, 2011).

Another definition by The Center for Disease Control (CDC) describes HAIs as follows: Healthcare-associated infections include central line- associated infections, urinary catheter-associated infections, surgical site infections within 3 months of date of surgery, and ventilator associated infections (VAP). Hospital associated pneumonia (HAP) is defined as radiographic evidence of infiltrates that were not present on admission and/or fevers developing greater than or equal to 48 hours after admission with radiographic evidence (2017). While the terms HAI and nosocomial infection (NI) are synonyms, for purposes of this project, the term HAI will be used.

Healthcare-associated infections are tracked global not only for information about the prevalence and cost but also the toll on lives lost related to these infections. Healthcare-associated infections are costly, with $96-$147 billion dollars a year spent in America. Also, in extremely ill patients, they can cause sepsis and death (Marchetti & Rossiter, 2013). Hill (2011) reported that the hospital stays for HAI methicillin-resistant Staphylococci aureus (MRSA) is an additional 10 days on average and Clostridium difficile (C-diff) adds 21 days on average to the length of stay (Hill, 2011).

Healthcare-associated infections are a global problem. In a global environment, privately insured verses nationally insured countries differ in who bears the cost. As an example, the USA has private insurance and any facility that incurs a HAI must endure the cost. In a country with a central government or social healthcare system, the country foots the entire cost of HAIs. The estimated direct and indirect cost of HAI in the USA acute healthcare setting is $96-$147 billion annually (Marchetti & Rossiter, 2013). These infections also add to mortality in acutely ill patients.

The cost of HAIs cannot be ignored. Research has shown that countries with national healthcare stress the importance of prevention. "*Bare Below the Elbow*" (2009) is an initiative in the United Kingdom emphasized by the Department of Health. No watches, bracelets, rings with high settings along with a ban on artificial nails are suggested for all direct health care providers in this initiative. Wedding bands are allowed; it is recommended that clothing should not extend past to elbow. These features encourage effective, preventative hand-hygiene.

Many objects in the environment can harbor microbes and become potential sources of infection or fomites. Fomites are any object that microbes can cling to and then become a means of transfer for the microbe (Taber's Dictionary, 2012). Stressors such as illness or surgical healing can decrease the body’s natural ability to protect itself. Invasive procedures and catheters add to the formula of the potential problem of a HAI (Gould & Dyer, 2011). By researching the prevalence of fomites within the healthcare setting, strategies can be developed to combat the problem. Everyday items travel from patient to patient daily in the hands of healthcare providers and the most benign of items such as pens (Wolfe, Sinnett, Vossler, Przepiora, and Enggretson, 2009) or telemetry monitors (Reshamuala, 2013) can spread infection. Even the clothing worn by the provider him/herself can transfer microbes throughout the healthcare settings (Hill, 2011). The healthcare providers themselves can become fomites A lab coat is a standard throughout the industry. It represents dignity to medical professionals as well as hope to the patients in their care (Qaday et al., 2015). Even the length of the coat is a symbol, with long coats traditionally reserved for the ‘attending’ medical staff members. The need to shelter patients from harm is a daily concern to health care providers. “Do no harm” is not just a saying, it is a pledge to the people that we care for and all efforts must be made to contain potential sources of microbial transfer.

The purpose of this paper was to conduct a systematic review exploring the microbial integrity of a very common object, the clinicians’ white coat.

Next, the review of the literature will be presented.

Literature Review

The search engine used was PubMed and search terms included “lab coat", "white coat", “fomite”, “nosocomial infection”, “healthcare-associated infection”, “standard precautions”, “immunocompromised host”, “infection control”, “microbial load” and "microbes". Terms that were discarded were "colonized", "contaminated”, “vector” and "dirty". The discarded terms were not selected because they were too broad. The words used in the search produced studies that were relevant to this research. No date limit was set if standard culture and sensitivity (C&S) technique was used. Up-to-Date was the search engine used to locate protocols and policies referred to in this proposal.

Introduction

In 1716, Dutch naturalist Antony van Leeuwenhoek was the first scientist to see sperm, protozoa, bacteria and other objects under his homemade microscope. ("Antony van Leeuwenhoek", 2012). He wrote of his discovery, but years passed before the Germ Theory was proposed by Louis Pasteur in the 1800’s (McEwen & Wills, 2014). Pasteur’s theory was highly ridiculed, but scientist persisted and other professionals, such as Dr. Joseph Lister, took note of the theory and more importantly, took steps based on it ("Dr. Joseph Lister: Medical Revolutionary", 1998). In the 1870’s, he was the first surgeon to wrap his post-operative incisions in dressings soaked in carbonic acid, resulting in a dramatic decrease in the mortality of his patients. He also agreed with Pasteur’s theory about washing hands and cleaning instruments between patients. Over 150 years passed between the discovery of microbes and the first seed of sterile technique, but the theory is now a standard in epidemiology research and procedures. (McEwen & Wills, 2014).

Objects in the environment can become fomites easily and not all objects are reasonably disposable. Fomites are any object that microbes can cling to and be transferred (Taber's Dictionary, 2012). The practice of single use equipment is not realistic in the average population and many pieces of equipment travel between patients. Lab coats are one of many objects that fomites can cling to for easy transport and transfer to another location. Universally, surgical attire is strictly monitored to control the entry of fomites into a very clean environment, the operating room environment and there is a strict ban on jewelry and artificial nails. This is necessary to prevent infection (Braswell & Spruce, 2012).

The WHO (2017) clarified healthcare-associated infections (HAI) as infections not present on admission and related to the care provided to the client. The CDC (2017) classifies HAI as infections obtained related to the use of central-line, urinary catheter or an infection acquired from intubation.

Healthcare-Associated Infections (HAIs): Incidence

The WHO compiled studies for a systematic review of the problem of HAI and added the categories of economic status to the equation (2011). "High" economic status countries were compared to "middle-low" economic status countries to divide the incidence of HAI linked to a countries prosperity. The United States of America (USA) had the lowest percentage of HAI at 4.5% while all other "high" status countries, including Europe, had a 7.6% rate. The "low-middle" economic status countries collectively had a rate of 19.1% HAI. The authors listed resources available and education level of the healthcare providers as reasons for the large disparity in numbers. Many countries with national forms of healthcare coverage consider HAI as a preventable loss of resources for the population.

Another review by researchers in Indonesia focused on developing countries. “Third-world” nations have a built-in disadvantage in that resources are scarce and limited (Murni et al., 2013). The authors reported that they have a HAI rate that is 2.5% higher than Europe and other developed countries and a rate of HAIs that is 4.24% higher than the USA.

Murni et al. (2013) conducted a systematic review; the initial search yielded 2507 articles and 34 were chosen based on inclusion and exclusion criteria. They also further broke the 34 studies down into those that focused on hand-hygiene, which included 22, with eight of them being solely hand-hygiene studies. Most of the studies were without a control group, but three were randomized controlled trials and three used controls before and after an intervention. Six of the studies were blind observation and 11 were deemed to be too short of a timeframe of observation. Only seven identified if findings were true or if they could be the result of contamination during the data collection. They concluded that hand-hygiene and antimicrobial stewardship were the two foci that stood out and that were achievable within their limited budgets. They also mentioned the need for greater diligence with ventilator-associated pneumonias (VAP), and catheter-associated urinary tract infections (CAUTI).

Ilic and Markovic-Denic (2017) compiled prevalence studies from 2003, 2005, and 2009 to assess data for analysis of HAI in a university hospital in Serbia. They used the CDC definition of HAI and focused on adverse reactions to an infectious agent or its toxins. This study was fueled by WHO's report of a disparity of HAI in under-developed countries verses developed countries. The clinical setting was a 1240-bed hospital with multiple departments. The studies were large: 764, 866, and 865 patients respectively were included in these studies. Only HAIs active on day of surveillance were included and there had to be no evidence of infection on admission. Asymptomatic bacteriuria was excluded.

The leading site of infection was the medical internal department in all three prevalence studies: 16 of 47 (34%) in first review; 12 of 40 (30%) in the second surveillance; and 36 of 75 (48%) in the third study. Urinary tract infections (UTI) were more prevalent in the second study, representing 18 of the 40 (45%) infections. In the third study, 25 of the 75 (33.3%) infections were attributed to the use of urinary catheters. Surgical site infections were the second leading cause of infection in the study, representing 18 of the 54 (33.33%) infections surveyed that day. The surgical unit was cited as the clinical area with the second most common HAIs in all three studies: 15% of 47(32%) infections out of 764 patients in study one; six of the 40 (10%) of infections out of 866 patients in the second study; and 25 of the 75 infections (33.3%) identified of the 865 patients reviewed in the third study. The decline in SSI in the second survey was attributed to the standardization of antibiotic prophylaxis which was implemented in 2005. The authors identified point prevalence as a limitation but mentioned with pride that Turkey is ranked 5th out of 12 in WHO's newly developed countries (Ilic & Markovic-Denic).

Vehicles of Transmission of HAIs

All objects are not reasonably disposable, and some equipment travels between patients as do staff members during a shift (Reshamwala et al. 2013). In the setting of rising cost of healthcare, all reasonable accommodations are made to protect our clients.

Telemetry units were the focus of investigation by Reshamwala et al (2013)**.** The purpose of this study was to evaluate the cleaning technique used by staff, which was to wipe with sodium hydrochlorite wipes. The design included random selection and culture of telemetry units using infection control standards. The colonization of this item was assessed before and after standard cleaning practice with disinfectant wipes by the staff of the hospital wards. The units each served as their own control. A total of 59 units were collected, 30 medical and 29 surgical. Before cleaning, 69% (n=40) of the units were positive for microbial growth. After cleaning, 24% (n=14) of the units still grew microbes by standard C&S collection and handling technique. The use of disposable leads was discussed but it was thought that they were cost prohibitive. This is a study that offered an expensive solution, disposable leads, but did not suggest an alternative to cleaning the units.

Other fomites that were investigated were pens; in a study by Wolfe et al. (2009), the authors collected them without warning. The pens had been in use throughout a night shift and a day shift in an ICU. The next step was to obtain C&S swabs. Twenty pens were collected from respiratory therapist and 17 grew bacterial contamination along with coagulase negative staphylococci. Micrococcus was found on four of the pens and oddly, one pen had no microbial colonization. This was explained when the user of the pen stated he used alcohol-based hand sanitizer (AHD) after every patient contact. The conclusion was that the AHD had transferred to and sterilized the pen. This fomite, a pen, is a very common object in all settings and does travel with the healthcare staff from room to room. It would be reasonable in an area such as ICU to designate pens to rooms and other areas to control the spread of infection, though this was not suggested by the authors of this research.

Electronics include computers, pagers, and mobile hand-held devices such as iPads and tablets. The healthcare community relies heavily on the electronic references available to assure quality, best-practice care. The devices are invaluable and save time and avoid costly mistakes. The problem is that the devices, just like the healthcare providers themselves, travel between patients. Ulger and Iejoma (2015) explored this phenomenon and used a systematic review format to report on this topic. Keyboard studies, results from dental and veterinary studies and pagers were excluded. The articles were from the time of 2005-2013 and 39 studies were included in the review. The total number of cultures throughout the 39 studies were 4,876. There was not a breakdown in terms of how many related to which devices. The range of colonization was from 10%-100%. Staphylococcus aureus was the predominant organism in 26 of the 39 (66.7%) studies followed by coagulase negative staphylococcus, 19 of 39 (48.7%). The cell phones were noted to be the perfect breeding ground since they are carried close to the body allowing for “perfect” humidity and temperature for bacterial growth (Ulger et al. (2015).

Food handlers at a hospital were studied as another vehicle of transmission in that the staff are in direct contact with patients and/or their food. Lazarevic, Stojanovic, Bogdanovic and Dolicanin (2013) compiled a retrospective analysis that examined infection rates before and after staff education of food handlers in Serbia. The cultures were obtained from hands and clothes of the workers along with work surfaces, equipment and utensils in both the central distribution kitchen and the satellite kitchens in facilities supplied by the central location. This study took place from 1995-2009, with an education program introducing regarding safe food handling, storage, cooking temperatures, and the personal hygiene of the employees themselves. This project was undertaken in Serbia with the Serbian health department controlling the smears and overseeing correct handling of all cultures. The results of the cultures led to implementation of an extensive education endeavor to aid in the decrease of cross-contamination leading to HAIs in a large Serbian hospital. The authors were affiliated with The School of Medicine, University of Nis, Serbia.

In 2005, the staff education program was implemented. The pre-teaching rate of cultures that grew potential pathogens was 25.8% (101 out of 391). After instruction, the rate dropped to 2.2% (15 out of 685) and almost twice the number of cultures were tested. The importance of the educational intervention became clear with the dramatic reduction. This study did span 14 years with 1995-2005 data as the pre-intervention phase and 2006-2009 data being used to demonstrate the effectiveness of the hand-hygiene campaign (Lazarevic et al. 2013).

Hospital fabrics and plastic colonization were explored in a well-controlled study by Neeley and Maley (1999). Five common hospital fabrics were inoculated with 22 gram-positive bacteria, both enterococci and staphylococci. Resistant and sensitive strains of both pathogens were used. The five fabrics were 100% cotton (clothing), 100% cotton terry (towels), 60% cotton-40% polyester blends (scrubs and lab coats), 100% polyester (privacy curtains), and 100% polypropylene plastic (splash guards). The cultures were checked daily with survival being assessed at 48 hours and daily beyond 48 hours. Two negatives were needed for declaration of non-viability of the organism.

This study of fabrics found that enterococci survived the longest, with the least being <12 days but the most being >90 days. Staphylococci lasted longest on splash guards, but all organisms survived at least one day. Staphylococci, both sensitive and resistant to methicillin strains, were placed in growth medium and stored and were checked daily for survival. The same technique was employed for enterococci, both sensitive and resistant to vancomycin. The organism that survived the longest was enterococci faecium, both sensitive and resistant, on polyester and polypropylene for over 90 days. These researchers compared their results with similar studies and concluded that the findings were validated (Neeley & Maley).

The American Journal of Infection Control published a study of linens washed and then treated by *Silvaclean* (registered trademark). Openshaw, Morris, Lowry and Nazmi (2016) examined the effects of *Silvaclean* treatment of gowns (N=1,912) and bottom sheets (N=2,074). A search of the *Silvaclean's* website found no association between the product, the company, and the authors of the research. In three hospitals that shared a laundering facility, pre-use and post-use sheets and gowns were cultured, treated with *Silvaclean,* and then re-cultured. Three trials were performed simultaneously using pre-patient use and post-patient use as guidelines. The total microbial load of the linens was assessed.

The most impressive statistic of this research was a 100% reduction of Staphylococcus aureus on the pre-patient use gowns. Methicillin sensitivity was not specified. In the post-patient use gowns, 860 of 1912 (45%) produced negative culture results. In the pre-patient use sheets, 1825 of 2074 (88%) cultured negative while post-patient use sheets, 622 of 2074 (30%). The control was colony counts before product application in comparison with colony counts after application of *Silvaclean.* The product does have to be applied by personnel wearing personnel protective equipment to protect the skin of the workers, which is thought provoking (Openshaw et al. 2016.).

Another study by Munoz-Price, Arheart, Millis, Cleary, DePascale, Jimenez, Fajardo-Aquino, Coro, Lubarsky and Birnbach (2012) examined physicians' washing habits of both scrubs and white coats in an undisclosed location. This study was provoked by rising concern that healthcare workers’ attire played a role in the transmission of pathogens. The design employed an anonymous questionnaire, which was distributed during weekly meetings of the medical, pediatric, and anesthesia departments. A total of 160 were completed; anesthesia providers completed 77, medicine completed 42, and pediatric 41. Specialty along with seniority were used to assess the results of the study. Status in terms of attending, staff, or student and laundering habits were the focus of the question.

The questionnaire asked specific details regarding washing methods and water temperature if the clothing was machine washed. The use of cold water was reported by 18 participants (11%), warm water by 33 participants (21%), hot water was reported by 82 responders (52%), dry cleaning reported by 10 (6%), and 17 reported (11%) that they did not know what temperature the uniforms were washed in. The water temperature was the most variable factor, with hot water being the final recommendation along with the use of bleach. Another conclusion was the need for education of the staff on the importance of clean scrubs and coats. Four respondents reported laundering the white coat > every 90 days. An anecdotal finding was that 29% of the physicians did report that wearing the white coat "made them feel like doctors” (Munoz-Price, 2012).

Preventative Measures

The WHO emphasizes the use of universal precautions to protect both the healthcare provider and the patient in the battle against HAI ("Standard precautions in health care", 2007). Strict hand-hygiene is at the base of this initiative to combat HAI on a global level. The use of strict standard precautions has been in practice since the HIV/AIDS diagnosis was uncovered in the USA in the 1980s. The use of masks, gloves, careful handling and disposal of sharp instruments and good hand-hygiene are highlighted along with the use of alcohol-based hand disinfectants (AHD). The WHO (2011) report *Clean Care is Safer Care* concluded with several suggestions. The report identified a need for expanded reporting of HAIs worldwide, as most of the available data was from mandatory reporting in America and Europe. By using the campaign *Clean Care is Safer Care,* WHO aims to globalize the fight against HAI with campaigns as simple as hand-hygiene to a loftier aim of collecting data globally to aid in combatting HAI. The WHO further claimed that the heart of healthcare systems worldwide is to prevent HAI. Global observation and surveys will impart valuable information in the battle to eradicate HAI. The WHO aims to insure at less minimal surveillance in developing countries with an increased emphasis on staff education along with stricter adherence to standard precautions. They also emphasized a need for increased research in these countries (2011).

Bare Below the Elbow (BBE) is a British initiative being headed by the Queensland Department of Health (2009). No artificial nails, bracelets, rings with stones or high settings and watches are allowed. The other stipulation is no garment that reaches below the elbow is permitted. Only wedding bands are spared in this attempt to decrease the spread of infection by emphasizing good hand-hygiene. The initiative is only in its' ninth year so little literature has been published to date on the outcome of this program, but it has been noticed world-wide and is mentioned in several articles about control of HAI.

Murni et al. (2013) examined the HAI problem in developing countries. Most of the studies included in the review of literature were from South American countries, Turkey, Indonesia, and Asia. Thirty-four studies met the criteria and 31 of them were conducted in tertiary, urban or teaching hospitals. Only interventional studies with the approach of systematic review, randomized controlled, quasi-experimental or sequential design were included. If studies were uniform in structure or a meta-analysis of specific interventions, they were included. Before and after interventions were analyzed to provide the data for this study. Hand-hygiene education, which was examined in 22 studies, was shown to be the leading reduction factors on the fight against HAIs. The authors concluded that hand-hygiene and antibiotic stewardship were the focus areas for improvement with P-values ranging from <0.0001 to of 0.02. The high economic burden to countries was mentioned as a driving force to institute better safeguards, which strengthens the link between the global nature of HAI and the economy.

The use of antibiotics directly before incision has been a focus of studies in the USA. The American Society of Anesthesiologists (ASA) examined data and recommended best practice techniques to limits HAI. The indication for prophylactic antibiotics is one-hour prior to incision with the two exceptions: vancomycin and fluoroquinolone should be administered two hours prior to incision, due to their longer infusion time ("Perioperative care: Timely administration of prophylactic antibiotics"

,2015). The rationale is that the appropriate timing of the antibiotics allows for maximum effect based on the half-life of the drug (ASA).

Interesting research was conducted by Nerazdiz, Sunkesula, Setlow, and Donskey (2015) regarding boosting alcohol-based hand sanitizers (ABHS). They explored the tools needed to increase ABHS to the same level of cleanliness as soap and water with spore forming microbes, including Clostridium difficile. By heating, acidifying or alkalization of the ethanol, they have demonstrated that it is possible to create a product that is quick and effective in the battle against spore forming microbes. The ineffectiveness of AHD is emphasized when dealing with C-diff contact. Anderson, Harris and Baron (2017) further expanded the theme to emphasize good hand-hygiene before and after every patient contact. Anderson et al. (2017) published a thorough review of standard precautions. This is a review of best practice along with guidelines. Standard precautions include but are not limited to hand-hygiene, the use of gloves and masks when appropriate along with "cough etiquette" and safe injection practices. They stated that the biggest barrier to standard precautions is the lax behavior related to adherence to the guidelines. Their summary included the recommendation that the CDC's guidelines for infection control should be followed along with a mention for the "*Bare Below the Elbow"* policy of the Queensland Department of Health. They also emphasized the use of three isolation categories including contact, droplet and airborne precautions in the battle to combat HAIs (Anderson et al., 2017).

Branch-Ellman et al. (2017) explored the risk and benefits of duel antibiotic coverage preoperatively using vancomycin along with a beta-lactam versus use of one or the other alone. The authors also examined the incidence of Clostridium difficile infections (CDI) within a 30-day time frame. The authors used a multicenter approach to the Veterans' Affairs cohort to compile data from October 1, 2008 to September 30, 2013 including data regarding cardiac surgery, joint replacements, vascular procedures, colorectal, and hysterectomies. The study evaluated duel antibiotic therapy verses standard single dose preoperative prophylactic coverage. Measures were adjusted for diabetes, smoking, American Society of Anesthesiologist Scores (ASA classification) and preoperative known methicillin-resistant Staphylococcus aureus (MRSA) status along with receipt of mupirocin. There was a total of 70,101 surgeries. The rate of infection did drop significantly with duel antibiotic prophylaxis, but the unwanted consequence was a spike in acute kidney injury (AKI). The rate of SSI was 2.3% (n=2,466) in combination therapy and 4% in patients receiving vancomycin alone (n=4/100). A seven-day incidence of AKI and 90-day incidence of CDI were also measured. The CDI incidence was similar in both groups. The risk of AKI in combined therapy was 23.8% (2,971/12,508) verses 20.8% (1,058/5,089). One limitation cited was the low ratio of hysterectomy patients included in the total of 70,101 surgeries (n=18).

The Patients' Perspective

In 2000, Tiwari, Abeysinghe, Hall, Perera, and Ackroyd conducted a study in the United Kingdom that included all adult inpatients at Princess Alexandra Hospital, Harlow, UK, except psychiatric patients. The purpose was to explore the statistical difference between Americans' and Brits' preferences of wearing a white coat. Patients were surveyed over two days using questionnaires that measured the British patients' preference regarding the topic of physicians' attire. Tiwari et al. performed this survey in response to American research regarding the patients' preferences of attire. The demographics collected included the age and sex of the patient. The attire preference was divided by male and female healthcare providers.

One hundred and sixty completed questionnaires were collected. Respondents included 72 males and 88 females. The average age of females was 65.5 years old with a range of 25-88 years old. The average age for male participants was 69 years of age with a range of 20-95 years. Neither gender showed a difference in whether the practitioner was male or female and wearing the white coat, but females demonstrated the higher preference for the lab coat (male 38%; n = 27 vs. female 63%; n = 55). They reported that the "majority" of Americans preferred white coat while only 48% of Brits were reported to have a preference. This result was concluded based on their prior investigation of American research into the preferences of American clients.

The patients' perspective tends to mirror the opinion stated above, that the white coat is a symbol of authority. Hueston and Carek (2011) surveyed 432 patients about their preferences regarding their physicians' attire. This was prompted by the move in some countries to change the culture of healthcare attire, such as Great Britain's *Bare Below the Elbows* initiative. This study was conducted in South Carolina and Ohio using a convenience sample from three adult primary care offices. Four hundred thirty-two participants were recruited to complete a two-part survey. A limitation was the diversity and cultures of the three practices: an urgent care facility where the staffs' attire ranged from formal to scrubs; a training facility that had a diverse culture; and one was in a private practice where more formal attire was worn.

The choices for preference of attire for the staff were formal, white coat, and tie for men and dresses with white coat for female providers, casual attire, and scrubs.

Twenty percent (n = 85) of the respondents preferred white coats over shirt and tie or dress and 24% (n = 102) did not prefer the tie, just dress shirt with white coat. Only 6%, (n = 25) preferred scrubs and 5% (n =21) had no preference if the provided appeared clean and neat. The results were divided without a clear preference except for a clear lack of preference for scrubs.

After the initial responses, the patients were provided with evidence regarding the reported microbial contamination of white coats and ties. The purpose of the second survey was to gauge the reaction of the clients when armed with knowledge about the cleanliness of the white coats. The second survey did provide a shift to no ties or white coats. The pre-information results favored white coat and tie when a preference was stated by 83% (n = 520) but this changed to 46% (n =199) when patients were given the further information about microbes.

Petrilli et al. (2015) performed a systematic review of patient perceptions of the physician attire. The search found 1040 studies of which 30 were selected representing 11,533 respondents. Fourteen countries were represented within these studies. The purpose of this review was to strengthen rapport between care givers and clients to maximize good health outcomes. The strengths of the study were a comprehensive review of studies with strict inclusion/exclusion criteria and filtering studies with conceptual understanding of the varied locations. The exact 14 countries were not listed. The weakness of the study was that the patient population varied by location, age, and context of care that was received. Results showed a preference of physician attire in 21 of 30 (70%) studies. Formal attire and ties were the preference in 18 of 30 (60%) studies with the preference being most noted in older patients. There was a 60%

preference for white coats with or without formal attire, but the Asian and European respondents did have an overall higher preference for formal attire under the lab coat.

Nursing Attire

Nursing attire was examined in Sweden with a burn unit as the site. Burn patients' skin integrity are especially vulnerable. Hambraeus (1973) examined the barrier gowns darned by the nurses over their uniforms. The unit had six beds with air filtration every 15 minutes on average. Staphylococci was the focus of the cultures. Nurses were aware of the study and consent was obtained. The participants were from various other units and wore barrier attire, either jackets and trousers or gowns, to perform the duties in the burn ward. The barrier garments were collected, kept separate, and cultured to assess the microbial load transfer from the uniforms underneath the barrier to the outside, the patient side, of the barrier garments.

The results were based on 57 protective outfits darned by the nursing staff. Staphylococci aureus-carrying particles did carry through the protective gowns. The staphylococci origin was traced using phage typing and the results identified that 19 were of patient origin, four were of staff origin, and 19 were of other origin. Of the 19 "other", further investigation matched those to members of the staff or patients on that ward. Both gowns and jackets were sterilized before use. Type of fabric, poplin or cotton, did not demonstrate a difference in the results.

A study by Gupta et al. (2017) found Staphylococci aureus second to Escherichia-coli microbial loads on sleeveless jackets traditionally worn by nurses in India. The site was 100 bed hospital in Delhi, India. Nurses' lab coats in India are like a utility vest without sleeves and with large front pockets. They were formerly made of

100% cotton but were changed to a cotton-polyester blend. Sterile patches of both cotton and cotton-polyester swatches were sewn onto the right and left pockets on the front of the coat. The nurses wore them for six hours and the right patches were removed and processed. The lab coats were kept and worn by the same nurse the next shift they worked. The left pocket swatches were then removed and processed. A patch of sterile cotton was used as a control and "planted" in the agar in the lab along with the swatches that were used by the nurses, as stated above. This study was well executed and showed a direct correlation to the purpose of the study: to assess the microbial integrity of the vest/ lab coats worn traditionally by nurses in India.

The samples were tested for seven pathogenic microbes including Staphylococci, Salmonella, Streptococci, Pseudomonas aeruginosa, Klebsiella, Escherichia-coli and Vancomycin-resistant enterococci. E-coli was the predominant microbe (47.8%) followed by Staphylococci (19.1%). Strep was the least found microorganism at only 2% discovery rate. The intensive care ward along with gynecology care ward showed the highest number of isolates of all organisms with the emergency department coming in third for microbial counts. All colony counts increased after a second use of the smocks and the recommendation was to only wear the smocks for one shift. Polyester fabrics overall had the higher level of contamination when compared to cotton/polyester blend fabrics.

Next, the framework that was used to guide this project will be presented.

Theoretical Framework

This research will be guided by Louis Pasteur's Germ Theory (Nies &McEwen,2011) and the PRISMA framework. Pasteur (1822-1895) revolutionized modern medicine with his hypothesis that a single microbe could cause disease and infection. Pasteur first proposed his theory in 1858 and met much resistance. Louis Pasteur lost three of his five children to typhoid fever, which may explain his interest in the cause of diseases (Bell, 2014). He received his degree in physics in 1847 after he had earned a degree in chemistry in 1842 (British Broadcasting Corporation [BBC], 1995). At the urging of Napoleon, he initiated research in the wine industry to improve fermentation. He did receive a U.S. patent for "Improvement in Brewing Beer and Ale Pasteurization" in the 1840's which, along with other discoveries led to his development of the germ theory. This theory is now mainly used in disease prevention and epidemiological studies (Masters,2011).

Louis Pasteur was instrumental in the development of vaccines and antibiotic therapies that are now routine in our standards of care. Pasteur studied molecules and his discoveries led to drug development, vaccines, and even the proposal of DNA. By proposing his "germ theory", he disputed the ancient beliefs that life happened spontaneously, and fleas grew from dust (BBC, 1995). Even the beliefs in magico-religious approach to medicine and the use of sorcerers (McEwen & Willis, 2014) were threatened by his theory.

Throughout history, the battle to reduce infection has driven medicine. Doctor John Snow used his belief in sewerage leaking into the public water supply on Broad Street in Soho, a London suburb, to battle a cholera outbreak in London in 1855 (Vachon, 2005). The prevailing theory of illness was thought to be “miasmas”, poison gases in the air and Dr. Snow met resistance for his insistence that germs were causing the outbreak. He famously removed the pump handle of the neighborhood water source most affected by this long and deadly outbreak. This effectively ended the outbreak by diverting the population to a different water pump. This act earned John Snow the title of “The Father of Epidemiology” (Nies &McEwen, 2011). In the 19^{th} and 20^{th} centuries, discoveries increased our ability to combat microbes (Egger, 2012).

The Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) (Moher et al., 2015) was used to guide this systematic review and is illustrated on the next page in Table 1. The Preferred Reporting Items for Systematic Review and Meta-Analyses is a guideline for the analysis of data gathered for a systematic review. The aim of this tool is to guide the author in the organization needed for a smooth and efficient analysis of the data. PRISMA includes a 27-item checklist with sections that include the title of the article to be included along with its abstract, introduction, methods, results, discussion, and funding. In each of these sections, detailed information to be summarized and reported is provided, along with rationales and supporting evidence as to why each item should be included.

Table 1

PRISMA Checklist

Table 1. **Checklist of Items to Include When Reporting a Systematic Review (With or Without Meta-Analysis)**

Section/Topic	Item #	Checklist Item	Reported on Page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome-level assessment (see Item 12).	
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group and (b) effect estimates and confidence intervals, ideally with a forest plot.	
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., health care providers, users, and policy makers).	
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review level (e.g., incomplete retrieval of identified research, reporting bias).	
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	

A four-phase flow diagram, illustrated in Figure 1, provides authors with a way to illustrate search results in a consistent and reproducible fashion.

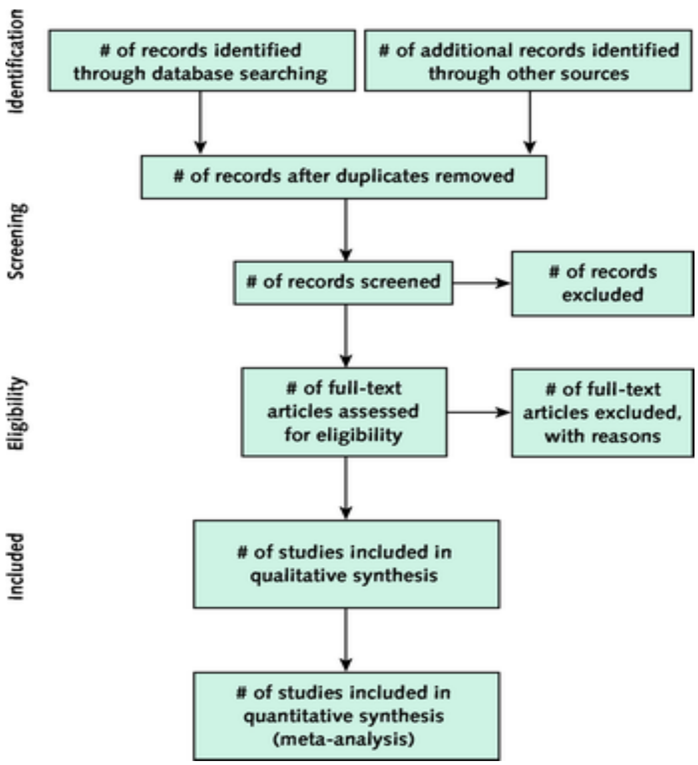

Figure 1. *Four-phase diagram to further assess data* (Moher et al. 2015)

The Annals of Internal Medicine published a thorough review of the PRISMA method of evaluating systematic reviews and meta-analyses along with the PRISMA 2009 checklist (Hutton et al., 2015). This method was chosen over the PRISMA-IPD method reported in JAMA (Stewart et al., 2015). Hutton et al. (2015) asserted that the original PRISMA method was superior to PRISMA-IPD methodology in reviewing medical systematic reviews and meta-analyses. The JAMA report was based on an on-line survey of an undisclosed number of researchers. JAMA (Stewart et al., 2015) has added three new items to the checklist. The first was evaluating the methods of checking the integrity of the IPD (individual participant data), randomization, data consistency, baseline imbalance and missing data. The second was reporting new issues that emerge from the data and the third was exploring variations.

The Critical Appraisal Skills Programme (CASP) method will be used to critically appraise selected studies. It was developed in 1993 at Oxford University under the direction of Sir Muir Gray specifically to aid healthcare workers assess research for best practice. (CASP-uk/history, 2017). In a review of best research tools, The University of South Australia lists CASP first in all subjects, except cohort studies, as the most useful way to assess scientific research papers (CASP, 2017)).

It consists of three broad categories with sub-categories: Are the results of the review valid? What are the results? Will the results help locally? The sub-categories include whether to continue in first phase, the precision of the results in the second category and were the results important and able to be applied in another setting. The CASP questions are illustrated in Table 2 on the next page.

Table 2

CASP Method

CASP Questions
"Did the trial address a clearly focused issue?" "Was the assignment of patients to treatments randomized?" "Were all of the patients who entered the trial properly accounted for at its conclusion?" "Were patients, health workers and study personnel 'blind' to treatment? "Were the groups similar at the start of the trial?" "Aside from the experimental intervention, were the groups treated equally?" "Were all the patients who entered the trial properly accounted for at its conclusion?" "How large was the treatment effect?" "How precise was the estimate of the treatment effect?" "Can the results be applied in your context?" "Were all clinically important outcomes considered?" "Are the benefits worth the harms and cost?"

(Oxman, Cook and Guyatt, 1994)

Next, the method will be presented.

Method

Purpose/ Clinical Question/Outcomes to be Examined

The purpose of this paper was to conduct a systematic review exploring the microbial integrity of a very common object, the clinicians' white coat.

The clinical question was: Do lab coats harbor microbes that are detrimental to the health of our patients?

Outcomes to be examined included standard C&S results and questionnaire results in seven of the eight studies.

Inclusion/Exclusion Criteria and Limits

Articles written in English, which displayed standard sterile technique in the method of collection of specimens and included detailed C&S results, were included in the review. The studies had to include microbial data regarding lab coats and have a database of greater than 25 lab coats to be included in the systematic review. No restrictions on study design were imposed. All studies had to involve lab coats.

Exclusion Criteria

Study exclusion criteria was any study with less than 25 reported C&S results. The studies were not limited by study design if standard C&S technique was clearly demonstrated.

Detailed Search Strategy

The search engines used were Medline, The Cochrane Library and Pub Med and the search words were "lab coat", "white coat", "nosocomial infection", "infection control", "Healthcare-associated infection", "microbial load" and "microbes". The phrase "of healthcare professionals" was later added and netted the dental studies. Terms that were considered then discarded included “contaminated”, “colonized”, and “dirty”.

Data Collection

Data collection tables were developed to illustrate the details of each selected study. The first table (Table 3) was formatted to include purpose, design, sample, and procedures. The second table was formatted to display C & S results, questionnaire results, conclusions, limitation and strengths.

Table 3

Purpose and Design, Sample, and Procedure

Purpose And Design	
Sample	
Procedure	

Table 4

C & S Results, Questionnaire Results, Conclusions, Limitations and Strengths

Data collection: Questionnaires, conclusions, limitations and strengths	
Culture And Sensitivity Results	
Questionnaire Results	
Conclusions	
Limitations And Strengths	

Assessment Criteria/ Critical Appraisal Tools

CASP was used to assess the scientific quality. Each selected study was assessed for scientific integrity using the CASP method. Any bias or weaknesses of the data was disclosed.

Descriptive Data Synthesis

After individual analysis of studies, the data were compared across the studies. A summative table of results was constructed to complete the cross-study analysis, as illustrated in Table 5 below.

Table #5

Cross study Analysis

	C&S results	*Recommendations Conclusions*	*Limitations Or bias*
Study #1			
Study #2			
Study #3			
Study #4			
Study #5			
Study #6			
Study #7			
Study #8			

Next, the results will be presented.

Results

All eight studies employed convenience sampling to net the subjects and all the subjects were physicians or medical students. In two studies, the medical students were studying dentistry. This approach was understandable given the very specific target, a clinician's white coat. Standard C&S technique was also a constant with all eight studies that used industry standard collection and handling of the specimens. The industry standard technique to collect a sterile specimen is to use a sterile cotton swab moistened with sterile saline and then swab the object. The specimens are then smeared on agar of various proteins and maintained at 37 degrees Celsius for incubation (Rothrock,2015). Each of the eight studies will be reviewed in detail in the narrative below, followed by critique of the study using CASP.

The purpose of the study by Wong, Nye and Hollins (1991) (N=100) was to explore the microbial load of white coats in an 800-bed facility in an East Birmingham hospital, exact location not disclosed. The 100 physicians also filled out questionnaires with demographics including the owner's dominant hand. The samples were collected from the owner's dominant hand pocket and the chest (Appendix A.1). This study was the only study of the eight that phage tested the staphylococcus aureus (S. aureus) samples to determine if they were normal flora to the owner of the coat or a pathogen picked up during rounds. Of the 25% of coats that grew Aureus, 11 (44%) phage tested to be the normal flora of the owner of the lab coat. The results were limited regarding reporting the C&S results. The questionnaire results focused on the usage of the coat and the time between laundering habit. No correlation was detected between organism growth and usage, but the bacterial load did increase with time (Appendix B.1). This study, along with others, stressed the importance of hand hygiene.

The CASP analysis (Appendix C.1) supported the theory of the cleanliness of the white coat being important to the goal of decreasing the occurrence of HAIs. A convenience sample of medical personnel only was used. The authors focused on the C&S results of 100 lab coats but did not provide all results for the reader. The extra step of phage testing S. aureus for the origin of the microbe was only done in this study. The results of the questionnaires were more thoroughly reported. All results were reproducible, and this research was sound and helpful to the topic of improving safety while handling white coats.

Muhadi, Aznamshah, and Jahanfar (2007) focused on the microbial contamination of the medical students' white coats (N=141) in Malaysia. The students were in various levels of training and filled out a questionnaire regarding sociodemographic information, perception of the coat, and handling habits of the garment (Appendix A.2). From the 141 cultured sleeves, S. aureus was found on only 32% of short sleeved coats verses 48.9% of the long-sleeved jackets. This study did differentiate long-sleeved from short-sleeved coats but did not supply all the results for a full analysis of the difference between the two styles of sleeves (Appendix B.2). The authors concluded that white coats were contaminated, and further studies are needed to assess the problem. Also, the authors recommended that white coats should be barred from non-clinical areas of the hospital.

The CASP analysis (Appendix C.2) supported that a convenience sample of only medical professional was recruited but did clearly focus on the question of the microbial integrity of the white coat. All results were reproducible but not fully reported. This study was also valuable in researching how to improve patient safety by improving how healthcare workers handle lab coats. This study produced clinically relevant results.

Priya, Acharya, Bhat, and Ballal (2009) conducted one of the two studies involving dentist and dental students. Due to the nature of dental work, the chest of the white coats and the sleeves of the dominant hand were cultured. These were the same sites of culture as used by Wong et al. (1991), the only medical study to culture the chest area of the white coats. Using standard C&S technique, 51 coats were tested using standard sterile technique (Appendix A.3). All coats showed some form of bacterial growth, with the chest areas being more contaminated than the sleeves from oral splatter. The cultures were broken down by gram-negative:(27.5%) faculty coats =12.5%, graduates =10.5% and interns = 17.5% or gram-positive (72.5%) faculties' coats =50%, graduates' coats =52.65% and interns' coats= 35%. The resistance to amoxicillin/ampicillin, which are frequently used antibiotics in India, was also a focus of the authors in this study (Appendix B.3). The conclusion was that the coats were a source of contamination and should be banned outside of clinical settings.

The CASP analysis (Appendix C.3) demonstrated another sample of convenience using dental students. The C&S results that were reported were all reproducible. The researchers did maintain focus on the clinical question in the quest to assess ways to handle lab coats with increased awareness of the risk of accidental cross-contamination. The authors completed a more in-depth reporting of C&S results and tested microbes for resistance to amoxicillin and ampicillin; both very common antibiotics used in India at the time of the study. The findings are relevant to practice.

Uneke and Iejoma (2010) explored the connection between HAI and clinicians' white coats. The study was sparked by the WHO global patient safety initiative with a goal of improving patient safety. The sample included 103 students and attending physicians, all volunteers. Questionnaires were filled out by all. Culture and sensitivity specimens of the mouths of pockets and cuffs of white coats were done with standard technique (Appendix A.4). Ninety-four (91.5%) coats were positive for microbial growth with diphtheroid (52.1%; n = 49) being the most common. The cuffs were more contaminated than the pockets (Appendix B.4) The questionnaires were used to assess demographics, laundering habits and agents used to launder the garments. There was no statistical difference between male and female participants. Fifteen (14.5%) washed coats daily, 20 (19%) washed weekly, 9 (8,7%) washed 3x/week and the majority, 58 (56%) washed coats twice/week. The conclusion was that there is a need for a plan to increase patient safety by mandating washing habits and replacement of white coats every year.

The CASP analysis of this study (Appendix C.4) did acknowledge the previously mentioned deficits of convenience sampling and no "intervention" in the conventional sense. The C&S results of this study, though not completely reported, were more extensive than some of the other studies and the survey statistics did account for all participants. All C&S results were reproducible, and the questionnaire provided useful data for analysis. This study also served to increase data toward safer handling of the white coats to improve the safety of patients.

In 2010, Treakle, Thom, Furuno, Strauss, Harris, and Perencevich strove to assess the British initiative "*Bare Below the Elbows*" (2009). The goal was to obtain data to judge whether white coats are fomites. The authors approached physicians attending grand rounds at Maryland Center in Baltimore. There were 149 participants, 109 medical and 40 surgical. The physicians cultured their own coats then filled out questionnaires regarding demographics and laundering habits (Appendix A.5). The C&S results were limited to only staphylococcus aureus and vancomycin-resistant enterococcus (VRE) (Appendix B.5). No VRE was cultured and the S. aureus was reported as 19/64 positive results were resistant to methicillin (MRSA). This was the only study found that was conducted in America. The conclusion was that a large percentage of white coats may be contaminated with S. aureus.

The CASP analysis of this study (Appendix C.5) demonstrated another sample of convenience and C&S results. Though only two microbes were reported, results were reproducible. This was the only study provoked by Britain's *Bare Below the Elbow* initiative and it was conducted only one year after the British initiative. The evidence produced by Treakle et al. did add to the body of evidence that safe standards of handling white coats would improve patient safety.

The goal of the study conducted by Banu, Anand and Nagi (2012) was to explore the type of microbial contamination of white coats worn by medical students. The sample consisted of 100 medical students with varying degrees of training including student, intern, and post-graduate. Questionnaires and C&S of collar, pocket, side and lapels were obtained (Appendix A.6).

The C&S results were only reported on three microbes: S. aureus (91%); Coagulase negative staphylococci (18%); and pseudomonas aeruginosa (19%). There with no difference between the white coats of male (65%) vs. female (35%) students.

The questionnaire delved into type of domicile and laundering habits of students (Appendix B.6). Sixty-seven percent reported that they “felt professional” while wearing the coats. The habitats were homes (41%) or hostels (59%). Eighty percent reported carrying the coats in bags to and from campus; Eighty nine percent of garments were washed within a private home verses 11% who utilized public laundry facilities. The conclusions were based on the combined information from the questionnaires and C&S results. The six recommendations were: yearly coat purchase; always owning more than two coats; weekly washings; excluding coats from non-clinical areas; use of protective clothing/standard precautions; and better hand-hygiene compliance needs to become standard.

The CASP analysis of the study (Appendix C.6) again revealed a convenience sample of medical students. The focus of this research was followed throughout the study and the evidence yielded the most extensive recommendations: 6 out of the 12 conclusions collectively accumulated. All results were reproducible and lend validity to the quest to improve patient safety by increasing diligence regarding the safe handling of the lab coats.

In 2012, the second study involving dental medicine was conducted. Malini, Thomas, Bhargava, and Girtia (2012) based their study on only C&S results and did not use questionnaires to explore the handling of the white coats. The researchers swabbed the white coats of 30 students and netted 46 cultures which were handled with standard C&S protocols (Appendix A.7). The cultures were reported as only cocci (73.9%) or bacilli (26.1%). The gram stain results were also reported with a further breakdown of species of bacteria.

The gram-positive results were broken down to 48.8% (n=11) coagulate-negative staphylococci, 4.3% (n=10) Streptococcus viridians, 21.7% (n=5) micrococci, 4,3% (n=1) pneumococci and 21.7% (n=5) Enterococcus faecalis. The gram-negative microbes were 47.8% (n=11) Neisseria catarrhalis. The gram-positive bacilli cultured were 30.1% (n=7) of the results and gram-negative bacilli were divided between 4.3% (n= 1) Escherichia coli, 8.7% (n=2) Klebsiella pneumonia and 8.7% (n=2) Pseudomonas aeruginosa (Appendix B.7). The conclusion was that the white coats were a potential source of contamination and plastic apron usage would be a beneficial addition to practice.

The CASP analysis of this study (Appendix C.7) revealed the smallest convenience sample of the eight studies. There was also a lack of full disclosure of the C&S results. There was no questionnaire; all conclusions were drawn strictly from the microbial evidence netted by the cultures. The results reported were reproducible and the conclusions did add evidence to the research into safer handling of white coats.

The last study was conducted by Qaday et al. (2015) in Kilimanjaro, Tanzania. The purpose was to determine the bacterial load on the white coats of medical doctors and students. A questionnaire was employed to collect demographic and laundering data. One Hundred and eighty participants collected their own swabs after tutorial. (Appendix A.8).

The authors reported that 73.33% of white coats (n=132) were contaminated and only 4.44% (n=8) reported that they wore their coats outside of clinical. This was the lowest percentage percent of use of coats outside the clinical area. The C&S results only reported S. aureus 90.91%(N=120), P. aeruginosa 6.82%(N=9) and E. coli 2.27%(N=3).

(Appendix B.8). The authors called for a revisit of the infection control and prevention policies at the location of the study along with increased vigilance regarding hand-hygiene.

The CASP analysis (Appendix C.8) netted the strongest convenience sample size (N=180) but a weak reporting of C&S results. Only three microbes were reported. The questionnaire results were inclusive. The authors did add to the growing body of evidence to support the need for standards of safe handling of lab coats to improve patient safety.

A cross study analysis of key findings of the eight studies was conducted (Appendix D). As previously reported, the C&S results were not reported in full in any one study, however they all validated the need to improve our handling of the white coat. Wong et al. (1991) was limited to only staphylococcus results while Malini et al. (2012) gave a detailed summary of results in their study of dental white coats. Only two studies reported on resistant organisms; Priva et al (2009) and Treakle et al. (2010). The other six studies all reported some results to confirm the presence of microbes and all reported detailed demographics and laundering survey results which were the meat of the data used to reach conclusions.

Appendix E illustrates a summary of the recommendations derived from the research of each individual study. Five of the studies concluded that increased vigilance and monitoring of infection prevention policies are necessary to aid in the battle to fight HAI (Banu et al., 2013; Malini et al. 2012; Muhadi et al., 2007; Qaday et al., 2015; Uneke & Iejoma, 2007). Three of the studies recommended vigilant hand-hygiene (Muhadi et al.; Uneke et al.2007; Wong et al., 1991), banning white coats outside of clinical areas (Muhadi et al. 2007; Qaday et al., 2015; Wong et al., 1991). and that the white coat is a potential source cross-contamination (Hollis, 1991; Muhadi et al. 2007; Wong et al., 1991). Only two studies, Muhadi et al. (2007) and Priva et al. (2009), blatantly stated that the white coat is a source of cross-contamination. All studies within the title, abstract or introduction stated the need for research regarding the microbial burden of the white coat. The less aggressive conclusions confirm the need for more research into this topic.

Next, summary and conclusions will be presented.

Summary and Conclusions

The World Health Organization (WHO) has identified healthcare associated infection (HAI) as a global problem (2011). The disparity between the risk of HAI in developed versus developing countries needs to be bridged: USA (4.5%); Europe (7.6%); and developing countries (19.1%). A common object, the white coat, may play a role in cross-contamination. This subject is a source of controversy due to the stature of the garment. Many clinicians wear lab coats and the coats are a symbol of authority, rank, and confidence and that is believed to deserve respect. Research to aid in the safe handling of the garment is needed to increase patient safety by decreasing HAI.

The research question that prompted this review was “Do lab coats harbor microbes that are detrimental to our patients?”. Guided by Louis Pasteur’s Germ Theory, this endeavor navigated the topic of the microbial integrity of the “white coat”. PRISMA (2015) was used to guide the selection of literature. The literature was carefully searched to explore HAIs, the role of fomites in transmission, and especially the clinicians’ white coats. Data collection tables were developed (Appendices A and B) to illustrate key design and outcomes data from the eight studies that met the inclusion criteria. The CASP measure (Oxman et al., 1994) (Appendix C) was employed to critically appraise the integrity of the eight studies. The key outcomes variable in all studies was the C & S of the lab coats; most other studies also surveyed participants and data such as demographics, professional position, student to attending, handling habits and laundering habits were also gathered. Cross study analysis of the eight studies is illustrated in Appendix D.

Overall, the eight studies showed microbial growth on lab coats. The results varied between medical and dental along with country to country, but no study reported a lack of microbes on the coats. No study full listed all C&S results. Wong et al (1991) was frequently referenced by other studies but it is unclear whether this is due to it being the first study of its kind or the strength of the research. It was the only medical study that phage tested the origin of the S. aureus to determine flora of owner verses pathogen. The reporting of the C&S results was sporadic in Malini et al. (2012) but this study provided the most detailed cultures while lacking a questionnaire. The authors based their three recommendations on C&S results and previous studies.

Banu et al (2012) recommended six of the 12 (50%) of the gathered conclusions for best practice in the handling of the white coat (Appendix D). Murhadi et al. (2007) was next with five of 12 (41.7%) (Appendix D). The only American study by Treakle et al. (2010) was the least inclusive with only one of 12 (8.3%) of the recommendations being recorded in conclusion and summary section of their study (Appendix D). This study also only reported MRSA and VRE results on surgeons' white coats although several other specialties were employed to gather the cultures.

The limitations of this systematic review were that all studies were samples of convenience. All subjects were physicians/dentist or medical/dental students. The authors or editors also limited access to full C&S results but were more inclusive with the questionnaire results. One study did not have a questionnaire but was included due to its inclusive C&S reporting.

In conclusion, the data extracted by this review confirmed the presence of microbes, some capable of spreading infection, on the surface of the clinicians' white coats. The questionnaires supplied data to create an educational and surveillance plan to combat HAIs. Data regarding laundering habits and handling of the coats led to recommendations to modify our habits with the coat which will potentially increase patient safety.

Next, recommendations and implications for advanced practice nursing will be presented.

Recommendations and Implications for the Advanced Practice Registered Nurse

Based on the data that was collected, the need for standardized policies for the handling of the white coat along with the diligent surveillance of practice adherence is needed. The strict use of hand-hygiene is of paramount importance. Also, the white coat needs to be considered a source of cross-contamination and further research is needed. Nurse practitioners can lead by example. We can make a difference in HAI by being more vigilant in our handling of the iconic symbol of the white coat. “Bare Below the Elbow” (2009) and half of the studies reviewed pointed to good hand-hygiene as the key to decreasing the spread of microbes between patients. As nurse practitioners we can be role models in the handling of white coats while working in a multidisciplinary team to implement surveillance protocols to enforce a standardized practice of the handling of the clinicians’ white coats. An interdisciplinary team would add to the search for solutions to increase patient safety by lessening the risk of HAI. We can lead by example as we search for further solutions and maintain the integrity of the symbol of medicine, the white coat.

Policies regarding safe handling practice should be instituted. Interdisciplinary exploration and refining of the topic could lead to a standard policy that could be taught to all direct patient care providers and then monitored for adherence. Lobbying at the state and national level, through professional organizations for example, could be valuable in continuing to strengthen initiatives to decrease HAIs.

Beneficence and nonmaleficence are ethical cornerstones of patient care. Several steps can be instituted to ensure the safety of our clients. There is a definite need for increased vigilance in laundering habits along with not using the coat outside of the clinical setting to prevent the spread of bacteria. The use of hand-hygiene and strict standard precautions, including the use of protective gowns and impenetrable aprons while performing wound care, would assist in decreasing the spread of infection.

A peer-teaching, team approach utilizing infection control, physicians, nurse practitioners and clinical nurse specialists could assist in maintaining the dignity of the coat while elevating the safe handling practices of the symbol that is the “white coat.” Strategies could include: development of standards and policies regarding laundering/ handling habits of white coats; development and implementation of educational initiatives and programs; surveillance by institutions to monitor practice adherence; and ideally, safe handling and laundering practices will be implemented nationally in medical and nursing schools’ curriculum to maximize the safety of clients.

Further research is needed with stronger designs and larger sample sizes. Continued exploration into ways to improve the safety of the patient by decreasing the risk of HAI is necessary. Handling and laundering improvements along with new C&S research will add to the body of knowledge regarding this topic.

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Appendix A

Table A.1 Wong, D., Nye, K., & Hollins, P. (1991). Microbial flora on doctors' white coats. *BMJ*, *303*(6817), 1602-4.	
Purpose And Design	The purpose of this study was to determine the microbial load of the white coats and the types of microorganisms. This was a cross sectional survey at East Birmingham Hospital, an 800-bed hospital in Birmingham. The language of the study leads the reader to believe that the study was conducted in England, but at no time does the study state that it was in England. The cultures were obtained from cuffs and pockets with the back of coats being cultured for "background flora". Questionnaires were also obtained.
Sample	N=100 The subjects sampled in the study were 100 physicians: 51 from medical, 38 from surgical an 11 from "other" were recruited.
Procedure	C&S of coats obtained from 3 sites on coats: cuffs, pockets and back. Contact plates were used by pressing them onto the fabric and they were all incubated for 18 hours at 37 degrees Celsius. Ten coats were taken from the facility laundry and used as controls. Any Staphylococcus aureus positive results were followed by a nose culture of the wearer of coat, phage testing of the microbe, to determine pathogen or normal flora of the clinician. The questionnaires were distributed and collected for data regarding laundering and usage habits.

Table A.2 Muhadi, S.A, Aznamshah, N.A., Jahanfar, S. (2007) A cross sectional study of microbial contamination of medical students' white coat. *Malaysian Journal of Microbiology, 3*(1) 35-38.	
Purpose And Design	This cross-sectional study's objective was to study the microbial contamination on medical students' white coats and to obtain data regarding the handling and laundering patterns of medical students towards their white coats. N=141 medical students in various levels of training will assess microbial load of coats and include within the questionnaire, sociodemographic data, how they handle and clean the coat along with their perception of a clean coat.
Sample	N=141 medical students at three different locations: Royal College of Medicine Perak, University of Kuala Lumpur and a private college attached to Ipoh General Hospital. The three locations form a part or the whole of (not specified) the Malaysian Royal College of Medicine (RCMP). The population of the subjects of the sample were 69.5% female, 30.5% male. The medical students represented all grades of education. Mean age was 22.04 +/- 1.495. Seventy-two students were non-clinical and 69 were clinical. No definition was provided for "non-clinical" vs. "clinical" subjects.
Procedure	After the questionnaires were filled out, swabs were taken in two different ways: (1) if long-sleeved the cultures were obtained from side, collar, pocket and sleeves or (2) is short-sleeved the cultures were taken from ide, collar and pocket. The swabs were then transported to lack to be streaked onto Nutrient agar and incubated overnight at 37 degrees C.

Table A.3 Priya, H., Acharya, S., Bhat, M., & Ballal, M. (2009). Microbial contamination of the white coats of dental staff in the clinical setting. JODDD, 3(4), 136-140.	
Purpose And Design	The goal of this research was to uncover the microbial load of white coats used by dental interns, graduate students and faculty in a free dental clinic in India. The authors conducted the study because there was no literature regarding dental white coats, only medical and nursing uniforms. This was a cross-sectional study of students and faculty. Questionnaires regarding laundering habits were also obtained.
Sample	N=51. The participants included graduate students, dental interns and faculty members. All the coats were full sleeved and made of cotton-polyester blend materials.
Procedure	Questionnaires were completed by participants. The samples were collected from the chest area and the pocket side of the owner's dominant hand. Samples were collected and transported to the microbiology department of Kasturba Medical College in Manipal, India. The samples were transferred to agar and held overnight at 37 degrees Celsius. Total bacterial count, gram-staining and antibiotic sensitivity were tested.

Table A.4 Uneke, C. J., & Iejoma, P. A. (2010, April). The Potential for Nosocomial Infection Transmission by White Coats Used by Physicians in Nigeria: Implications for Improved Patient-Safety Initiatives. *World Health & Population*, *11*(3), 44-54.	
Purpose And Design	This study was instigated by the work of the World Health Organization and their global initiative for increased patient safety. The hypothesis of the authors was that since no study has clearly linked the white coat to HAI, they would conduct a study and attempt to form the link. This was a cross-sectional survey with questionnaires filled out by participants.
Sample	N=103 at Ebonyl State University Teaching Hospital in Abakeliki, Nigeria. All physicians were volunteers and a mix of consultants (attending) and registrars (students) were involved. The breakdown was as follows: ER n= 24, Med n=23, Pedi n=14, OG/GYN n=14, OP n=9, Surg n=19
Procedure	Questionnaires were filled out by all volunteers. C&S of cuffs and mouths of pockets were obtained with standard technique then transported to the microbiology lab of the university. Assay testing for culture count and gram-stain was done by authors and antibiotic resistance was also tested against antibiotics common to the region.

Table A.5 Treakle, A.M., Thom, K.A., Furuno, J.P., Strauss, S.M., Harris, A.D., Perencevich, E.N. (2010 June 28). Bacterial contamination of health care workers' white coats. American Journal of Infection Control 37(2): 101-105.	
Purpose And Design	To assess the white coat as a fomite in the presence of the original British "Bare Below the Elbow" initiative. The authors wished to obtain data regarding transient colonization of white coats and the connection to nosocomial infections. This was a cross-sectional study done within the United States. Questionnaires were also obtained.
Sample	N=149 at University of Maryland Medical Center in Baltimore, MD: a 669-bed inner-city tertiary care hospital. When statistics were calculated, four participants were not accounted for in the survey. The attendants of "grand rounds" were approached. The authors only approached physicians and all subjects of the study were physicians. Medical n=109 Surgical n=40
Procedure	The participants filled out questionnaires. After a demonstration, the participants obtained their own cultures of the pockets, cuffs and lapels of their coats. The cultures were incubated at 37 degrees Celsius for 24-48 hours and assessed for pathogens. The positive cultures were further analyzed. The surveys were filled out answering questions regarding: demographics and laundering habits. Demographics included status, specialty and last contact with an in-patient along with the participates perception of the cleanliness of the coat. Laundering habits were judged by frequency and location of laundering, not specific details regarding the laundering agents.

Table A.6 Banu, A., Anand, M., & Nagi, N. (2012, June 11). White coats as a vehicle for bacterial dissemination. *Journal of Clinical & Diagnostic Research*, *6*(8), 1381-1384.	
Purpose And Design	To determine the level and type of microbial contamination present on the white coats of medical students to assess the risk of transmission of pathogenic microorganisms by this route in a hospital setting. Cross-sectional survey of the microbial load of the coats. Survey was done to assess the demographics, attitude towards the use of the white coats, perception of the coats, and the laundering habits of the students.
Sample	N=100, medical students have varying degrees of training: student, intern or post-graduate. This was conducted at a tertiary level hospital attached to a medical college in India. 65% (n=65) were male, 35% (n=35) were female, 83% (n=83) were students, 10% (n=10) were interns, 7% (n=7) were post-graduates.
Procedure	A self-administered questionnaire was obtained from the 100 volunteer participants. The C&S specimens were obtained using standard technique. The sites selected for culture were collar, pocket, side and lapels of the white coats. All specimens went directly to the Department of Microbiology and were handled at 37 degrees Celsius using standard technique. The cultures were tested for antibiotic resistance in this study.

Table A.7 Malini, M., Thomas, T. K., Bhargava, D., & Girtia, S. (2012). Microbiology of the white coat in a dental operatory. *Indian Journal of Dental Research, 23*(6), 841-45.	
Purpose And Design	Analyze microbiological burden on white coats in clinical departments of a dental college and hospital. Cross-sectional survey of white coats in a dental college.
Sample	Undergraduate students in various clinics, interns, and post-graduate students. N=30 swabs from 30 coats. N=46 cultures from the 30 swabs.
Procedure	Swabbed 30 coats which netted 46 cultures. Cultures were analyzed for colony morphology on culture plates, gram stain slides and the biochemical characteristics of the colonies were studied using standard protocols.

Table A.8 Qaday, J., Sariko, M., Mwakyoma, A., Kifaro, E., Mosha, D., Tarimo, E., & Shao, E. (2015, November 4). Bacterial contamination of medical doctors and student's white coats at Kilimanjaro Christian Medical Centre, Moshi, Tanzania. *International Journal of Bacteriology*. Article ID 507890, 5 pages.	
Purpose And Design	To determine the bacteriological load on white coats of medical doctors and students and the associating factors. Cross-sectional study with survey to collect demographic data and details regarding usage and washing habits of the participants.
Sample	N=180 Sex: Male n=118 (65.6%), Female n=62 (34.4%) Staff Position: Medical doctors 60 (33.3%), Medical students n=120 (66.7%) Department: Surgical n=80 (44.4%), Nonsurgical n =100 (55.6%) Duty Station: Inpatient n=150 (83.3%), Outpatient n=30 (16.7%)
Procedure	The swabs were self-collected by the participants but in this study, they were instructed on correct technique before the collection. The sites of collection were the right and left pocket mouths, lapels and sleeves of the coats. The samples were handled by the microbiology lab in standard fashion and inoculated into blood agar cultures and held at 37 degrees Celsius overnight before testing was performed.

Appendix B

Table B.1 Wong, D., Nye, K., & Hollins, P. (1991). Microbial flora on doctors' white coats. *BMJ*, *303*(6817), 1602-4.	
Culture And Sensitivity Results	N=25 (25%) of coats grew S. aureus on cuffs and pockets. Of those 25, 11 (44%) phage tested to match the normal flora of the wearer. No pathogenic gram-negative bacilli were isolated. There was no full breakdown of every organism isolated offered in the text.
Questionnaire Results	The medical specialties break down was: n=51(51%) medical, n=38 (38%) surgical and n=11(11%) "other". Coat usage results were as follows: n=55 (55%) used coat greater than 75% of time, n=29 (29%) used coat 50-75% of time and n=16 (16%) reported using the coat less than 50% of the time. Time between laundering did vary widely but no correlation was made between the organisms grown on each coat was reached but the amount of bacterial load did increase with time.
Conclusions	The authors did conclude that white coats are a potential source of spread of bacteria. The authors recommended weekly washing routines. The importance of hand-hygiene and need for improvement of hand-hygiene was the third conclusion by authors.
Limitations And Strengths If applicable	Limitations: this was a convenience sample. Limited C&S results were published by the journal. The authors used controls but no results for the 10 control coats were included. The exact location of the study was not disclosed, though the language used did suggest that the study was conducted in a British hospital. The method was contact plate to obtain specimens. This gives only a surface result, but the authors did not wish to mutilate the coats for deep specimens. A strength of this study was it was the only study that phage tested S. aureus to obtain source: owner of coat verses another source Six of the 7 following studies do list this as a reference for their research.

Table B.2 Muhadi, S.A., Aznamshah, N.A., Jahanfar, S. (2007). A cross-sectional study of microbial contamination of medical students' white coat. *Malaysian Journal of Microbiology*, *3*(1) 35-38.	
Culture And Sensitivity Results	S. aureus- 32% short sleeved and 54% long-sleeved Bacillus was reported on 18.8% of long-sleeved coats. No information was provided for short-sleeved coats. Clinical vs. nonclinical practice was determined to be statistically insignificant.
Questionnaire Results	The questionnaire revealed that 68.9 (48.9%) thought white coats were always contaminated while 59 (41.9%) thought they were clean if no stains were visible. Another 13 (9.2 %) stated that the coat was clean if the collar and pockets were visibly clean. One 121 (85.8%) agreed that the coats carried germs while 126 (89.4%) agreed that the white coats transmitted germs.
Conclusions	The authors concluded that white coats are contaminated. Authors concluded that standard guidelines are needed for the safe handling and cleaning of white coats. The other conclusions were that students should be barred from wearing coats in non-clinical areas. The other suggestion was to wear aprons and wash hands when handling wounds.
Limitations And Strengths If applicable	Limitation: This was a convenience sample and the article did not include full breakdown of microbial findings or the resistant/sensitive to antibiotics data. Not all results were published. Another limitation was that there was not a control group. Strength: separated short vs. long sleeved coats Also, the study did separate genders when reporting results but a later study by Banu et al (2012) did dispute that finding. Muhadi et al found the coats of females to be more contaminated than their male counterparts.

Table B.3 Priya, H., Acharya, S. Bhat, M., & Ballal, M. (2009). Microbial contamination of the white coats of dental staff in the clinical setting. *JODDD*, *3*(4), 136-140.	
Culture And Sensitivity Results	The chest area of the coats showed the highest are of contamination followed by the pocket of the dominant hand. No coat showed 0% growth. Gram-positive organisms were isolated on n=26 (50%) of faculty coats. N=10 (19.6%) of graduate coats and N=17 (35%) of intern coats. Gram-negative findings were broken down as n=3 (5.8%), n=4 (7.8%) and n=7 (13.7%) respectively. Of the total microbes cultured in the study, 27.5% were gram-negative microbes. Of the entire study results, 60% were resistant to Amoxicillin/ Ampicillin which is a common antibiotic in India.
Questionnaire Results	The population of the study was 49% (n=25) male and 51% (n=26) female. The group is further broken down as 23.5% (n=12) faculty, 37.3% (n=19) graduate students and 39.2% (n=20) interns. The majority, 94.1% (n=48) self-graded their white coat as “not clean”. Laundering was reported as 1 (2%) every month, 2 (3.9%) every fortnight, 60.8% (n=31) every week, 25.5% (n=13) twice a week and 7.8% (n=4) reported a daily washing habit.
Conclusions	The white coat is a source of bacterial contamination and should be considered a potential source of cross-contamination. Unlike medical white coats, dental white coats had highest contamination on chest area. There is enough data to support banning white coats outside the clinical setting.
Limitations And Strengths If applicable	The weakness of this study was that the authors and editors failed to show C&S results in detail using gram stain as the dividing factor between the microbes and it was a sample of convenience. Strength was that the material of the coats was provided in the information presented in the article. Strength: was that the authors looked for common “oral” flora to assess the coats in the presence of the nature of dental medicine. Strength: Study shows that the dental community is paying attention to HAI research.

Table B.4 Uneke, C. J., & Iejoma, P. A. (2010, April). The potential for nosocomial infection transmission by white coats used by physicians in Nigeria: Implications for improved patient safety initiatives. *World Health & Population*, *11*(3), 44-54.	
Culture And Sensitivity Results	Ninety-four (91.5%) of the coats were contaminated. No coats displayed mixed contamination. The most common microbes isolated were diphtheroid (52.1%). Cuffs were more contaminated than pockets. The microbial load was as follows: S.aureus 18 (19.1%) P.aeruginosa 9 (9.3%) Diphtheroid 49 (52.1%) GNB 18 (19.1%)
Questionnaire Results	The questionnaire assembled information regarding demographics, usage, laundering habits including frequency and agents used, and cadre (description of the length of the coat. Another fact explored was the number of coats owned by the participants. Demographics were displayed in sample section. Laundering habits were divided without statistical significance between males and females. The frequency of laundering was the following: Daily n=15 (14.5%), Once per week n=20 (19%), twice per week n=58 (56%), three x week n=9 (8.7%). Specialties were also reported in the sample section of this report. Number of white coats possessed by the participants were one coat n=19 (18.4%), two coats n=51 (49.5%) and three coats n=23 (22.3%).
Conclusions	The need for a patient safety initiative was deduced from the data. The initiative would include a yearly purchase of white coat and the owning of two or more coats at all times being mandatory. Also, weekly washing of coats will be mandatory along with a ban of white coats in nonclinical areas. Hospital and physician management will be involved with monitoring of compliance with incentives used for compliance.
Limitations And Strengths If applicable	Limitation listed by authors was that they could not link HAIs to white coats beyond a shadow of a doubt and that it was a sample of convenience. Strength: Overall, a strong study that reinforced Priya et all (2009) study that bans the use of white coats outside of clinical setting. Strength: This was a study that did a detailed breakdown of the microbes compared to the other seven studies. The authors or editors also included a very detailed questionnaire result section in this article.

Table B.5 Treakle, A.M., Thom, K.A., Furuno, J.P., Strauss, S.M., Harris, A.D., Perencevich, E.N. (2010 June 28). Bacterial contamination of health care workers' white coats. American Journal of Infection Control. 37(2): 101-105.	
Culture And Sensitivity Results	Staphylococcus aureus was isolated on the coats of 19 out of 64 (30%) resident physicians. While MRSA isolates were found on the coats of 4 out of 31 (13%) attending physicians. No VRE was isolated.
Questionnaire Results	The breakdown of status was 38 students (26%), 64 residents (43%), 12 fellows (8%) and 31 attendings (21%). Four participants were not accounted for in the final tally of the data. The most common reason given for "why do you wear white coat?" was professionalism.
Conclusions	The authors concluded that a large percentage of health care workers' white coats may be contaminated with S. aureus.
Limitations And Strengths If applicable	One limitation of the study was that full questionnaire results were not included. Another limitation was that this was a convenience sample and that the participants cultured own coats. A demonstration was conducted, and it was "assumed" that the population could proceed with cultures. The authors only focused on 2 pathogens. No control groups were used to validate data. Two strengths of this study were the large sample size and the authors were the only American physicians found in this search who addressed this topic, HAI relationship to white coats.

Table B.6 Banu, A., Anand, M., & Nagi, N. (2012, June 11). White coats as a vehicle for bacterial dissemination. *Journal of Clinical & Diagnostic Research*, *6*(8), 1381-1384.	
Culture And Sensitivity Results	S. aureus 91%, Coagulase negative Staphylococci 18%, P. aeruginosa 19%. The sites were all contaminated: lapels were 19.5%, sides were 28.9%, and pockets and collars composed the remaining contaminants with no statistical difference between the two sites. Unlike Muhadi et al (2007) there was no statistical difference between the microbial load of coats owned by females vs. males.
Questionnaire Results	The study participants were 65% male and 35% female. The students were divided as 59% staying in hostels vs. 41% in homes which raised the question of bringing microbes into the community. The majority, 67% of students, wore their coats to appear professional while 80% indicated that they carry coats in bags. Thirty-nine reported washing coats at least twice a week, n=32 for once a week and n=26 for once every 2-4 weeks. Only three reported washing coats monthly or greater. Home washing was reported as n=89 (89%) vs. n=11 (11%) in laundry facility other than home. Seventy-seven students perceived the white coats as contaminated.
Conclusions	Purchase white coats yearly. The owning of two or more coats should be compulsory. Coats should be washed weekly. Exclude coats from nonclinical areas. Based on other studies, better hand hygiene should also be practiced. Making use of universal precautions, such as protective gowns, should be considered.
Limitations And Strengths If applicable	Limit: Small sample per authors and a sample of convenience. Swabs vs. sweep-plate methods were used to obtain specimens. The students did swabs. There was no control group and that it was a sample of convenience. Also, the significance of colonized vs. non-colonized was not identified. Limit: The students (n=80) who stated they carried their coats in bags were not asked to expand that answer. An encouraging majority (n=82) responded that they only used white coats in hospital. Strength: This study solidifies the need to ban white coats from nonclinical areas, as previously stated, and increased vigilance with hand-hygiene. Strength: The authors' attention to the domiciles of the students and the risk of transporting pathogens into the community.

Table B.7 Malini, M., Thomas, T. K., Bhargava, D., & Girtia, S. (2012). Microbiology of the white coat in a dental operatory. Indian Journal of Dental Research, *23*(6), 841-45.	
Culture And Sensitivity Results	The morphology of cultures was n=34 (73.9%) cocci, n=12 (26.1%) bacilli. The gram stains of the cultures were n=23 (50%) gram-positive cocci, n=11 (23.9%) gram-negative cocci, n=7 (15.2%) gram-positive bacilli, n=5 (10.8%) gram-negative bacilli. Gram-positive cocci results were: Coagulase-negative staphylococci n=11 (47.8%), Streptococcus viridians n=1 (4.3%), micrococci n=5 (21.7%), Pneumococci n=1 (4.3%, Enterococcus faecalis n=5 (21.7%). The gram-negative cocci Neisseria catarrhalis were found in n=11 (47.8%) of samples. Gram-positive bacilli were found in n=7 (30.1%) of samples. Gram-negative bacilli results were: Escherichia coli n=1 (4.3%), Klebsiella pneumonia n=2 (8.7%), Pseudomonas aeruginosa n=2 (8.7%)
Questionnaire Results	N/A. This was the only study that did not conduct a questionnaire to assess the correlation between the demographics of the group to the microbial findings of the cultures.
Conclusions	White coats are a potential source of cross infection. Recommended that donning of impenetrable clothing such as plastic aprons and gloves or changing the materials of the white coats.
Limitations And Strengths If applicable	Limitations of this study were that no questionnaire was included and that it was a sample of convenience. Strength: The detail of the C&S results. Strength: Study shows that the dental community is paying attention to HAI research as it is the second study of a dental nature used in this review.

Table B.8 Qaday, J., Sariko, M., Mwakyoma, A. Kifaro, E., Mosha, D., Tarimo, E. & Shao, E. (2015, November 4). Bacterial contamination of medical doctors and students' white coats at Kilimanjaro Christian Medical Centre, Moshi, Tanzania. International Journal of Bacteriology. Article ID 507890, 5 pages.	
Culture And Sensitivity Results	A total of 132 (73.33%) of coats tested positive for contamination. S. aureus: n=120 (90.91%) P. aeruginosa: n=9 (6.82%) E. coli: n=3 (2.27%)
Questionnaire Results	As reported in sample, the study included 118 (65.6%) males and 62 (34.4%) females who were then divided based on status: student or physician. Eighty (44.4%) subjects were surgical and n=100 (55.6%) were "non-surgical". Only 8 (4.44% reported wearing coat outside of clinical. The breakdown of washing habits was as follows 10 (5%) reported going longer than 7 days between washings while the majority n=120 (67%) reported less than 3 days between washings. The remaining n=50 (28%) fell between the other 2 groups.
Conclusions	The authors of this study called for a revisit of the infection control and prevention policies of this institution along with an increased vigilance regarding hand-hygiene.
Limitations And Strengths If applicable	Limitations of the study were that it was a sample of convenience, incomplete C&S result reports, the demographics did not fully break down specialties or include agents used in laundering habits, and participants performed their own swabs, although they were instructed in technique as was the case in previous surveys. Strength: Large sample size of 180 participants. This is also a response to WHOs initiative to increase vigilance in emerging nations and the authors have demonstrated a willingness to rise to the challenge of increasing patient safety by decreasing HAI.

Appendix C

Table C.1 Wong, D., Nye, K., & Hollins, P. (1991). Microbial flora on doctors' white coats. *BMJ*, 303(*6817*), 1602-4.

"Did the trial address a clearly focused issue?"

Yes

"Was the assignment of patients (subjects) to treatments randomized?"

No. A sample of convenience was employed in this study. All subjects were physicians or medical students

"Were all of the patients (subjects) who entered the trial properly accounted for at its conclusion?"

Not all cultures were reported in the conclusion, but the survey reports did include all subjects.

"Were patients, health workers and study personnel 'blind' to treatment?

No

"Were the groups similar at the start of the trial?"

Yes

"Aside from the experimental intervention, were the groups treated equally?"

No intervention but all subjects were treated equally.

"How large was the treatment effect?"

N=100 subjects without treatment.

"How precise was the estimate of the treatment effect?"

N/A

"Can the results be applied in your context?"

Yes

"Were all clinically important outcomes considered?"

No

"Are the benefits worth the harms and cost?"

Yes

(Oxman, Cook and Guyatt, 1994)

Table C.2 Muhadi, S.A., Aznamshah, N.A., Jahanfar, S. (2007). A cross-sectional study of microbial contamination of medical students' white coat. *Malaysian Journal of Microbiology*, 3*(1)* 35-38.
"Did the trial address a clearly focused issue?" **Yes** "Was the assignment of patients(subjects) to treatments randomized?" **No. A sample of convenience was employed in this study. All subjects were medical students.** "Were all of the patients(subjects) who entered the trial properly accounted for at its conclusion?" **No, not all cultures were reported in the conclusion, but the survey reports did include all subjects.** "Were patients, health workers and study personnel 'blind' to treatment? **No** "Were the groups similar at the start of the trial?" **Yes** "Aside from the experimental intervention, were the groups treated equally?" **No intervention but all subjects were treated equally.** "How large was the treatment effect?" **N=141 subjects** "How precise was the estimate of the treatment effect?" **N/A** "Can the results be applied in your context?" **Yes** "Were all clinically important outcomes considered?" **No** "Are the benefits worth the harms and cost?" **Yes**

(Oxman, Cook and Guyatt, 1994)

Table C.3 Priya, H., Acharya, S. Bhat, M., & Ballal, M. (2009). Microbial contamination of the white coats of dental staff in the clinical setting. *JODDD*, 3(*4*), 136-140.
"Did the trial address a clearly focused issue?" **Yes** "Was the assignment of patients to treatments randomized?" **No. A sample of convenience was employed in this study. All subjects were dental students or dentist.** "Were all of the patients (subjects)who entered the trial properly accounted for at its conclusion?" **Not all culture results were present in conclusion of study. The survey results did account for every subject.** "Were patients, health workers and study personnel 'blind' to treatment? **No** "Were the groups similar at the start of the trial?" **Yes** "Aside from the experimental intervention, were the groups treated equally?" **No intervention but all subjects were treated equally.** "How large was the treatment effect?" **N=51** "How precise was the estimate of the treatment effect?" **N/A** "Can the results be applied in your context?" **Yes** "Were all clinically important outcomes considered?" **No** "Are the benefits worth the harms and cost?" **Yes**

(Oxman, Cook and Guyatt, 1994)

Table C.4 Uneke, C. J., & Iejoma, P. A. (2010, April). The potential for nosocomial infection transmission by white coats used by physicians in Nigeria: Implications for improved patient safety initiatives. *World Health & Population*, 11(*3*), 44-54.
"Did the trial address a clearly focused issue?" **Yes** "Was the assignment of patients (subjects) to treatments randomized?" **No. A sample of convenience was employed in this study. All subjects were physicians or medical students.** "Were all of the patients (subjects) who entered the trial properly accounted for at its conclusion?" **All culture and survey results were reported at end of study.** "Were patients, health workers and study personnel 'blind' to treatment? **No** "Were the groups similar at the start of the trial?" **Yes** "Aside from the experimental intervention, were the groups treated equally?" **No intervention but all subjects were treated equally.** "How large was the treatment effect?" **N=103** "How large was the treatment effect?" **N/A** "How precise was the estimate of the treatment effect?" **N/A** "Can the results be applied in your context?" **Yes** "Were all clinically important outcomes considered?" **No** "Are the benefits worth the harms and cost?" **No**

(Oxman, Cook and Guyatt, 1994)

Table C.5 Treakle, A.M., Thom, K.A., Furuno, J.P., Strauss, S.M., Harris, A.D., Perencevich, E.N. (2010 June 28). Bacterial contamination of health care workers' white coats. *American Journal of Infection Control* 37(*2*): 101-105
"Did the trial address a clearly focused issue?" **Yes** "Was the assignment of patients (subjects) to treatments randomized?" **No. A sample of convenience was employed in this study.** "Were all of the patients (subjects) who entered the trial properly accounted for at its conclusion?" **Not all culture results were presented in conclusion. Only 145/149 subjects' surveys were accounted for in the conclusion.** "Were patients, health workers and study personnel 'blind' to treatment?" **No** "Were the groups similar at the start of the trial?" **Yes** Aside from the experimental intervention, were the groups treated equally?" **No intervention but all subjects were treated equally.** "How large was the treatment effect?" **N=149**"How large was the treatment effect?" "How precise was the estimate of the treatment effect?" **N/A** "Can the results be applied in your context?" **Yes** "Were all clinically important outcomes considered?" **No** "Are the benefits worth the harms and cost?" **Yes**

(Oxman, Cook and Guyatt, 1994)

Table C.6 Banu, A., Anand, M., & Nagi, N. (2012, June 11,2012). White coats as a vehicle for bacterial dissemination. *Journal of Clinical & Diagnostic Research*,6(*8*).
"Did the trial address a clearly focused issue?" **Yes** "Was the assignment of patients (subjects)to treatments randomized?" **No. A sample of convenience was employed in this study. All subjects were physicians or medical students.** "Were all of the patients (subjects) who entered the trial properly accounted for at its conclusion?" **Not all culture results were presented at conclusion. The survey did account for all participants.** "Were patients, health workers and study personnel 'blind' to treatment? **No** "Were the groups similar at the start of the trial?" **Yes** "Aside from the experimental intervention, were the groups treated equally?" **No intervention but all subjects were treated equally.** "How large was the treatment effect?" **N=100** "How precise was the estimate of the treatment effect?" **N/A** "Can the results be applied in your context?" **Yes** "Were all clinically important outcomes considered?" **No** "Are the benefits worth the harms and cost?" **Yes**

(Oxman, Cook and Guyatt, 1994)

Table C.7 Malini, M., Thomas, T. K., Bhargava, D., & Girtia, S. (2012). Microbiology of the white coat in a dental operatory. *Indian Journal of Dental Research*, 23(*6*),841-45.
"Did the trial address a clearly focused issue?" **Yes** "Was the assignment of patients (subjects)to treatments randomized?" **No. A sample of convenience was employed in this study. All subjects were dentist or dental students.** "Were all of the patients (subjects) who entered the trial properly accounted for at its conclusion?" A**ll culture results were presented at in conclusion. No questionnaire was used in this study.** "Were patients, health workers and study personnel 'blind' to treatment? **No** "Were the groups similar at the start of the trial?" **Yes** "Aside from the experimental intervention, were the groups treated equally?" **No intervention but all subjects were treated equally.** "How large was the treatment effect?" **N=30** "How precise was the estimate of the treatment effect?" **N/A** "Can the results be applied in your context?" **Yes** "Were all clinically important outcomes considered?" **No** "Are the benefits worth the harms and cost?" **Yes**

(Oxman, Cook and Guyatt, 1994)

Table C.8 Qaday, J., Sariko, M., Mwakyoma, A. Kifaro, E., Mosha, D.Tarimo, E. & Shao, E. (2015, November 4). Bacterial contamination of medical doctors and students' white coats at Kilimanjaro Christian Medical Centre, Moshi, Tanzania. International Journal of Bacteriology. Article ID 507890, 5 pages

"Did the trial address a clearly focused issue?"

Yes

"Was the assignment of patients (subjects) to treatments randomized?"

No. A sample of convenience was employed in this study. All subjects were physicians and medical students.

"Were all of the patients (subjects) who entered the trial properly accounted for at its conclusion?"

All culture results were reported in conclusion. Also, all questionnaire results were reported in this study.

"Were patients, health workers and study personnel 'blind' to treatment?

No

"Were the groups similar at the start of the trial?"

Yes

"Aside from the experimental intervention, were the groups treated equally?"

No intervention but all subjects were treated equally.

"How large was the treatment effect?"

N=180

"How precise was the estimate of the treatment effect?"

N/A

"Can the results be applied in your context?"

Yes

"Were all clinically important outcomes considered?"

No

"Are the benefits worth the harms and cost?

Yes

(Oxman, Cook and Guyatt, 1994)

Appendix D

Key to Appendix D

Study #1- Wong, D., Nye, K., & Hollins, P. (1991). Microbial flora on doctors' white coats.

Study #2- Muhadi, S.A, Aznamshah, N.A., Jahanfar, S. (2007) A cross sectional study of microbial contamination of medical students' white coat.

Study #3- Priya, H., Acharya, S., Bhat, M., & Ballal, M. (2009). Microbial contamination of the white coats of dental staff in the clinical setting.

Study #4 -Uneke, C. J., & Iejoma, P. A. (2010, April). The Potential for Nosocomial Infection Transmission by White Coats Used by Physicians in Nigeria: Implications for Improved Patient-Safety Initiatives.

Study #5 -Treakle, A.M., Thom, K.A., Furuno, J.P., Strauss, S.M., Harris, A.D., Perencevich, E.N. (2010 June 28). Bacterial contamination of health care workers' white coats. American Journal of Infection Control 37(2): 101-105.

Study #6- Banu, A., Anand, M., & Nagi, N. (2012, June 11). White coats as a vehicle for bacterial dissemination.

Study #7 Malini, M., Thomas, T. K., Bhargava, D., & Girtia, S. (2012). Microbiology of the white coat in a dental operatory.

Study #8- Qaday, J., Sariko, M., Mwakyoma, A., Kifaro, E., Mosha, D., Tarimo, E., & Shao, E. (2015, November 4). Bacterial contamination of medical doctors and student's white coats at Kilimanjaro Christian Medical Centre, Moshi, Tanzania.

Appendix D

Cross study Analysis

	C&S results	*Recommendations/Conclusions*
Study #1	Limited to Staphylococcus aureus: 25% (N=25) with 44% (N=11/25) phage testing to the owner of the white coat.	1. White coats are a potential source of spread of infection 2. Should be washed weekly *3.* Hand-hygiene is important
Study #2	Although this study showed promise by differentiating long-sleeved from short-sleeved coats, the full results were not reported. Bacillus 18.8% of long-sleeved. S. aureus was 32% short and 56% long-sleeved coats. This does add validity to *"Bare Below the Elbow"* (2009).	1. White coats are contaminated 2. Standard guidelines are needed for the handling of the white coat. 3. No coats outside of clinical area. 4. Wear aprons when handling wounds. 5. Hand-hygiene is important
Study #3	The chest area of the coat was more contaminated than the pocket of the owner's dominant hand. The sample breakdown was gram positive; 19,6% (N=10) graduate students, 50% (N=25) faculty and 35% (N=17) interns. Gram negative; 12.5% (N=3) graduate student 10.5% (=4) faculty 17.5% (N=7) interns 60% of microbes were resistant to Amoxicillin & Ampicillin	1. White coat is a source of bacterial contamination 2. Potential source of cross-contamination 3. Dental white coats are most contaminated on chest *4.* No white coats outside of clinical area.

Cross study Analysis-continued

	C&S results	*Recommendations/Conclusions*
Study #4	91.5% (N=94) of the coats were contaminated: S. aureus 19.1% (N=180 Diphtheroid 52.1% (N=49 P. aeruginosa 9.3% (N=9) GNB 19.1% (N=18)	1. Need for safety initiative which would include: ➢ Yearly purchase of white coat ➢ Owning 2 or > at a time ➢ Weekly washing ➢ No white coat outside of clinical area.
Study #5	S. aureus was only microbe reported: 30% (19/64) residents While MRSA was found on 13% (4/31) of the coats of attending physicians. No VRE was isolated	The authors concluded that a large percentage of health care workers' white coats are contaminated with S. aureus
Study #6	Limited results included: 91% (N=91) S. aureus with 18% (N=18) being coagulase negative staphylococcus P. aeruginosa found on 19% (N=19) of the coats	1. Yearly purchase of white coat 2. Owning 2 or more should be compulsory 3. Wash coats weekly 4. No coats outside clinical area 5. Good hand-hygiene 6. Universal precautions/aprons/gowns

	C&S results	*Recommendations/Conclusions*
Study #7	The morphology of cultures was n=34 (73.9%) cocci, n=12 (26.1%) bacilli. The gram stains of the cultures were n=23 (50%) gram-positive cocci, n=11 (23.9%) gram-negative cocci, n=7 (15.2%) gram-positive bacilli, n=5 (10.8%) gram-negative bacilli. Gram-positive cocci results were: Coagulase-negative staphylococci n=11 (47.8%), Streptococcus viridians n=1 (4.3%), micrococci n=5 (21.7%), pneumococci n=1 (4.3%, Enterococcus faecalis n=5 (21.7%). The gram-negative cocci Neisseria catarrhalis were found in n=11 (47.8%) of samples. Gram-positive bacilli were found in n=7 (30.1%) of samples. Gram-negative bacilli results were: Escherichia coli n=1 (4.3%), Klebsiella pneumonia n=2 (8.7%), Pseudomonas aeruginosa n=2 (8.7%)	1.White coats are potential sources of cross-infection 2.Aprons/gloves 3.Change material coat is made from.
Study #8	73.33% (N=132) were (+) for microbes. Only 3 were reported: S. aureus 90.92% (N=120) P. aeruginosa 6.82% (N=9) E. coli 2.27% (N=3)	1. The authors called for review of institution's infection control policies. *2.* Good hand-hygiene

Appendix E

Recommendations of the Authors:

Distribution of Recommendations per Study